

2017

Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students

Ellen Prescott
Walden University

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Walden University

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Ellen Prescott

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Walden University
2017

Abstract

Examining the Relationship Between Math Achievement and Self-Efficacy in

Developmental Math Students

by

Ellen Louise Prescott

MA, Northern Arizona University, 2011

BS, Arizona State University, 2008

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Education

Walden University

November 2017

Abstract

Many students today lack preparedness for college-level math. Colleges and universities offer developmental math courses; however, students are failing these developmental courses and they often have low math self-efficacy. Educational technology and alternative classroom models are used to try to alleviate low success rates in developmental math courses. The purpose of this study was to examine the relationships between math self-efficacy and math achievement in students in developmental math courses that used the software platform Connect Math. Research questions focused on self-efficacy and math achievement differences between students in computer mediated and traditional lecture-based developmental math courses, as well as differences in their opinion of Connect Math. Guided by self-efficacy theory, a quasi-experimental study was conducted and data from students in traditional lecture-based ($n = 81$) and computer-mediated ($n = 76$) developmental math courses was analyzed. ANCOVA analysis revealed a significant relationship between age and math self-efficacy, $p = .042$ and a significant relationship between class type and student's perceived helpfulness of Connect Math, $p = .005$. Analysis also found a difference in GPA with computer-mediated students having a slightly higher GPA than traditional lecture-based students. Furthermore, results indicated instructor significantly predicted student opinion of Connect Math, $p = .023$. Results suggest that greater access to technology did not significantly predict greater success in the developmental math course. With higher completion rates of developmental math courses, colleges and universities could see greater graduation rates for all students.

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Dedication

This dissertation is dedicated to my children Nile, Kai, and Avery and my husband, Bennie for their never-ending love and support; to my parents, Ellick and Elke Ruffin, and my sister, Mary Ruffin, for believing in me. I love you all very much.

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Table of Contents

List of Tables	v
List of Figures	vi
Chapter 1: Introduction to the Study.....	1
Background.....	1
Problem Statement	5
Purpose of the Study	6
Research Questions and Hypotheses	6
Theoretical Framework.....	9
Nature of the Study	9
Definition of Terms.....	10
Assumptions.....	11
Scope and Delimitations	11
Limitations	11
Significance.....	12
Summary	13
Chapter 2: Literature Review	14
Introduction.....	14
Research Strategies	14
Developmental Education Defined.....	15
Developmental Mathematics	18
Technology Integration in Classrooms	20

Technology Integration in Developmental Math Courses	22
MyMathLab	24
Connect Math	28
Course Selection	29
Theory of Self-Efficacy	30
Summary	33
Chapter 3: Research Method.....	35
Introduction.....	35
Research Design and Rationale	35
Methodology.....	38
Description of Population	38
CPP Developmental Math Program.....	39
Sampling and Sampling Procedure.....	39
Procedures for Recruitment, Participation, and Data Collection	40
Instrumentation and Operationalization of Constructs	42
Threats to Validity	44
Ethical Procedures	44
Summary	45
Chapter 4: Results.....	46
Introduction.....	46
Data Collection	48
Time Frame, Actual Recruitment, and Response Rates	48

Descriptive Statistics for Demographic Characteristics	49
Results	51
Research Question 1	51
Research Question 2	55
Research Question 3	60
Research Question 4	62
Research Question 5	64
Further Findings.....	64
Summary.....	65
Chapter 5: Discussion, Conclusions, and Recommendations.....	68
Introduction.....	68
Interpretation of the Findings.....	70
Limitations of the Study.....	74
Recommendations.....	75
Implications.....	76
Conclusion	79
References.....	81
Appendix A: Questionnaire	93
Appendix B: Initial Email.....	101
Appendix C: Second Email.....	102
Appendix D: Introduction to Study Paragraph	103
Appendix E: Survey Permission #1	104

Appendix F: Survey Permission #2 106

List of Tables

Table 1. Demographics for Overall Sample ($N = 157$).....	50
Table 2. Math Self-Efficacy Responses.....	53
Table 3. Overall Means of Student Opinion of Connect Math.....	63

List of Figures

Figure 1. Highest completed math course in high school.....64

Chapter 1: Introduction to the Study

Background

For centuries, societies have depended on their ability to create advances in exploration/commerce, health/medicine, defense, finance, and technology (US Department of Education, 2008). Quantitative reasoning is an important skill to possess in order to be successful in any of the aforementioned areas (Elrod, 2014). A lack of US citizens available for these types of jobs can result in job outsourcing and/or understaffing of positions. Additionally, those without a college degree (on average) make less than those with college degrees (U.S. Bureau of Labor Statistics, 2017). With a college degree, people can become positive, successful, contributing members of the US economy, while also increasing their median earnings (U.S. Bureau of Labor Statistics, 2017).

Higher education has become progressively more accessible since the establishment of community colleges. However, all colleges are facing a challenge. With an increase in the number of students who have access to higher education, there are greater variances in the education level and preparedness of the students (Holt, Holt, & Lumadue, 2012). A growing number of students are entering college who are underprepared for college-level coursework (National Association for Developmental Education, 2013). Developmental math has one of the highest enrollments of the three types of developmental classes available, English, reading, and math (Bonham & Boylan, 2012). Developmental education programs (also known as remedial course programs) were created at community colleges and universities to help underprepared students in math, English, writing, and sometimes science, be able to achieve the dream of

attending college and earning a higher education degree (Bonham & Boylan, 2012).

Developmental courses are designed to help students who are not properly prepared for college level work by completing a course (or sequence of courses) that will provide the necessary background information to take college courses (National Association for Developmental Education, 2013). While providing college-prep courses seems like the perfect solution for underprepared students, colleges still face a problem with student success rates (Daiek, Rusinko, & Talbert, 2012). Peterson, Woessmann, Hanushek and Lastra-Anadon (2011) stated that the U.S. ranked 32nd in the world for proficiency in mathematics, in addition to only 32% of U.S. eighth graders being proficient in mathematics. Colleges and universities have provided a way for underprepared students to be able to attend their institutions, yet students are still failing these developmental math courses.

Mathematics education is important, not only for society, but also for the individual, as it offers a greater number of college and career options (US Department of Education, 2008). America's math students have been struggling. Community colleges across the nation experience low levels of student success in developmental math courses (Gerlaugh, Thompson, Boylan, & Davis, 2007). In higher education, students take a placement test or have previous coursework be considered before placement into developmental math courses (Blum et al., 2007). Once students are placed in developmental math courses, successful completion of these developmental mathematics courses are necessary to take ensuing college-level courses (Blum et al., 2007). The outcome of these courses can affect college success/graduation. Of US high school graduates, fewer than half are prepared to take college-level math courses (Bissell, 2012).

Adelman (2004) estimated that 41% of college students enroll in remedial courses at some point during their college career. Some students are unable to attain their educational goals because they do not succeed in these courses (Bonham & Boylan, 2012).

Remedial courses have been found to be beneficial to underprepared students, according to studies that examine academic outcomes of students in developmental math courses. After tracking students long-term, Waycaster (2011) found that developmental math students and nondevelopmental math students achieved similar success in later math courses. Likewise, Bahr (2008) found no significant difference when he compared the long-term academic outcomes of successful remediated students to those who achieved college-level math skill without remediation. This may indicate that remedial math programs are highly effective for those students who actually complete the program.

Studies that examine student academic outcomes in developmental math courses that use educational technology have found mixed results. Kodippili and Senaratne (2008) sought to examine whether computer-generated homework (via MyMathLab) led to an increase in academic performance in comparison to traditional instructor-generated homework and found no significant difference in performance on homework assignments between the students in the MyMathLab group and controls; however, results showed that students in the MyMathLab group had higher success rates than the traditional students (70% success rate in the final grade for MyMathLab students vs. 49% success rate with traditional-based students). MyMathLab is an interactive computer-learning environment that includes course materials and tools (Pearson Education, 2012). Bissell (2012) suggested that in order to create a more personalized teaching

and learning experience for both regular and developmental math students, instructors should make use of open educational resources. Trenholm (2006) examined how computer technology can be used to increase learning success and retention, but results did not indicate a clear relationship between learning efficacy and computer use. While various educational technology tools are being used to help students be more successful in their developmental math courses, there are mixed results as to their effectiveness.

While student motivation and hard work are key components to student success, low self-efficacy toward coursework can hinder students' ability to successfully complete the coursework and eventually graduate (Spence & Usher, 2007). Self-efficacy, the strength of one's belief in their ability to complete a task or goal, is a significant predictor of math success and plays an important role in developmental math courses (Spence & Usher, 2007). The experience of long-term negative emotions toward mathematics and math anxiety caused by frequent course failures should be addressed to improve students' success in math courses (Taylor, 2008). In order to achieve success in math courses, students need to have positive self-efficacy.

Technology is one potential tool that can be used to help increase engagement and self-efficacy, while also decreasing math anxiety in students who struggle with mathematics. Instructors must find appropriate educational technology and determine the best way to use available technology to enhance student motivation and learning (Keengwe, Onchwari, & Wachira, 2008, p. 4). Low successful completion rates of students in developmental math courses shows that there is a need to find the most effective way in which to teach the needed material so these students can not only pass these courses, but also eventually graduate.

Problem Statement

Despite the success of the students who do complete developmental math courses across America, colleges report low levels of successful completion of these developmental math courses, with only about 68% of students completing such courses with a grade of C or better (Gerlaugh, Thompson, Boylan, & Davis, 2007). Studies show that during both 1995 and 2000, student enrollments in remedial courses in 2- or 4- year colleges and universities were at 28% (Parsad, Lewis, & Greene, 2003). Students who successfully complete remediation courses are as successful in college as nonremediation students (Bahr, 2008; Waycaster, 2011). Therefore, once students successfully complete their remedial courses, there are no academic differences between them and nonremedial course students.

While researching the effectiveness of educational technology has been common in recent years, especially for math, I found no peer-reviewed and scholarly studies concerning the relationship between self-efficacy and math achievement in developmental math students who use Connect Math at the college level. Additionally, no recent studies were found on the state of developmental/remedial math education in California. The sample for this study came from California State Polytechnic University, Pomona. This study focused on students enrolled in developmental math courses that utilized educational technology to gain further insight on relationship between self-efficacy and math achievement.

There is a need for better understanding of how the use of educational technology (e.g. MyMathLab, Connect Math, Webassign) enhances student self-efficacy in developmental math education (Keengwe et al, 2008; Trenholm, 2006; Wenglinsky, 1998). With this understanding,

more students will be able master basic mathematical knowledge and skills, potentially increase their math self-efficacy and, therefore, be more likely to continue in their college experience through graduation. This study focused on Connect Math because it is one of the education technology tools widely used in colleges around the United States.

Purpose of the Study

The purpose of this quantitative study was to examine the relationships between math self-efficacy and math achievement in students in computer-mediated and traditional lecture-based developmental courses that utilize Connect Math, and also examining their opinion of Connect Math. Responses to a survey were collected from students in developmental math courses and were inductively compared with the final grades of the students who participated in the study. Results from this study can be used to: understand how Connect Math affects student self-efficacy; differences in self-efficacy between computer-mediated and traditional lecture-based courses; and understand differences in student opinion (i.e. attitude, perspective, perceived helpfulness) of Connect Math in computer-mediated and traditional lecture-based courses in comparison to math achievement. The outcomes of the study are being made available to empower educators and instructional technology designers to better understand and facilitate learning for students in developmental math courses.

Research Questions and Hypotheses

1. Is there a significant difference between math self-efficacy in students enrolled in courses using Connect Math in computer-mediated math courses and traditional lecture-based developmental math courses?

H_01 : Math self-efficacy was lower than or no different for students enrolled in computer-mediated courses compared to traditional lecture-based courses.

H_11 : Math self-efficacy was greater among students enrolled in computer-mediated courses compared to traditional lecture-based courses.

2. Was there a difference in opinion (i.e., attitude, perspective) of Connect Math based on delivery method (computer-mediated vs. traditional lecture-based)?

H_02 : There was no difference in opinion of Connect Math based on delivery method (computer-mediated vs. traditional lecture-based).

H_12 : A negative opinion of Connect Math was more prevalent among students who were in traditional lecture-based courses.

3. Was there a significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses?

H_03 : There was no significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses.

H_13 : There was a significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses, with computer-mediated students having higher achievement than traditional lecture-based students.

4. Did opinion (i.e., attitude, perspective) of Connect Math relate to math achievement among students in developmental math courses and did this relationship differ by class delivery mode?

H₀4: There was no relationship between opinion and math achievement and this relationship did not differ by course delivery type.

H_{1a}4: Negative opinion was related to lower achievement, and the relationship was stronger in traditional courses compared to computer-mediated courses.

H_{1b}4: Positive opinion was related to greater achievement, and the relationship was stronger in computer-mediated courses compared to traditional courses.

5. Did math self-efficacy mediate the relationship between class delivery mode and math achievement?

H₀5: Math self-efficacy did not mediate the relationship between class delivery mode and math achievement.

H₁5: Math self-efficacy mediated the relationship between class delivery mode and math achievement. Specifically, there was a direct effect of class delivery mode on math achievement (*H₁3*) such that computer-mediated instruction with Connect Math predicted greater math achievement than traditional course delivery. Computer-mediated instruction predicted higher self-efficacy, and higher self-efficacy predicted greater achievement. There was full or partial mediation such that self-efficacy explained the relationship between class delivery mode and math achievement.

Theoretical Framework

According to Bandura's self-efficacy theory, a person's perception of completing a goal will influence whether they actually complete the goal (Bandura, 1997). Four principal sources of information construct self-efficacy: enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states (Bandura, 1997). By examining the relationship between math self-efficacy and math achievement, this study seeks to get closer to understanding how the use of Connect Math is positively related to self-efficacy.

Nature of the Study

A posttest-only control group quantitative design was used to analyze the relationship between student self-efficacy and math achievement of students in lecture-based and computer-mediated developmental math courses that utilize Connect Math. The independent variable in this study was the instructional delivery method (lecture-based and computer-mediated). Control variables included student gender, sex, age, race/ethnicity, and instructor. The dependent variables included self-efficacy, students' opinion toward Connect Math, and math achievement. Final course grades served as the measure of math achievement for this study. The participants self-selected a developmental math course (beginning and intermediate algebra) they placed into (i.e., they chose whether they wanted a computer-mediated course or traditional lecture-based course). The study consisted of multiple classes that were all developmental math courses (either beginning or intermediate algebra), with some courses computer-mediated and some courses traditional lecture-based. There were 157 students from California State Polytechnic University,

Pomona who participated in the study. The selected sample included students who tested into the developmental math course and elected to partake in the study.

Definition of Terms

Anxiety: Fear or distress over possible negative undertakings (Bandura, 1997).

Computer-mediated instruction (CMI): The effective use of computer and/or technology to support and facilitate teaching and learning (Bull, Kimball & Stansberry, 1998). In the context of this dissertation, it also represents the course that had reduced classroom hours and relied more heavily on the use of Connect Math to help instruct students.

Computer self-efficacy: The belief in one's ability to use a computer successfully (Spence & Usher, 2007).

Connect Math: An online assignment and assessment platform hosted by ALEKS corporation (McGraw-Hill Education, 2017).

Developmental education: Coursework in reading, writing, or math designed to help underprepared students grasp basic competency skills required to perform college-level work (Parsad et al., 2003).

Math anxiety: Fear, tension, or apprehension that causes an interference with math performance (Ashcraft, 2002).

Math self-efficacy: The belief of one's ability to solve math problems and successfully complete mathematical tasks (Zimmermann, Bescherer, & Spannagel, (2011)).

Remedial education: Coursework in reading, writing, or math designed to help underprepared students grasp basic competency skills required to perform college-level work (Parsad et al., 2003).

Self-efficacy: The beliefs of one's capabilities to complete a task (Bandura, 1997).

Technology: Computer-based applications and computer/web-based instruction and practice (Raines & Clark, 2011).

Assumptions

It was assumed that the students would be honest in their responses and that the survey responses represented the attitudes, feelings, and perceptions of student participants. It was also assumed that the instruments were valid measures of the constructs. Lastly, it was assumed that the final grades would be accurate reflections of students' success in the developmental math courses.

Scope and Delimitations

Since this study is confined to California State Polytechnic University, Pomona students in developmental math courses, it did not include outside situational factors of the students. Furthermore, this study did not include time spent studying outside of the class and/or tutoring for the class material. Connect Math was the only technology examined in the study.

Limitations

Since this study was confined to students in developmental math courses, the generalizability of the study may be limited to students who test into developmental math courses. Only two types of developmental mathematics courses were part of this study:

beginning and intermediate algebra. The findings may be limited to students enrolled in courses traditional lecture-based and computer-mediated developmental math courses that utilize Connect Math. The findings may also be limited to students within a specific demographic area.

Significance

Teachers from all levels of education are constantly searching for effective ways in which to instruct students. As technology touches more and more areas of our society educators tend to look toward technology as a possible method of aiding in the education of students (Keengwe, Onchwari, & Wachira, 2008). Results from this study can be used to inform instructors of traditional lecture-based courses and computer-mediated courses on how Connect Math affects students' math self-efficacy. Educators must be mindful "of the factors that foster student achievement in diverse class settings and with different tools" while creating technology for student use, or else it will be a waste of time (Spence & Usher 2007, p. 284). Understanding how the use of Connect Math impacts students' math self-efficacy can help instructors determine whether to use Connect Math in their developmental math courses. By understanding students' perspectives and attitudes, developmental course instructors can differentiate their instruction and tailor it to the needs of the students (Holt et al., 2012). At the societal level, this research can help inform how instructional technology impacts math-self efficacy. From this study, researchers can look for more ways to increase math self-efficacy in students needing remedial help using instructional technology. More students becoming successful in their remedial classes can have a positive impact on college retention and graduation rates, which also leads to a more educated society.

Summary

The overall low student success rate of students in developmental math courses across the country was the driving force for this study. The study involved students in traditional lecture-based and computer-mediated developmental math courses who utilized Connect Math, at California State Polytechnic University, Pomona. As a result of better describing the relationship between math self-efficacy and math achievement in developmental math courses, it is possible to provide information on how to improve both instructional technology and math pedagogy.

The first chapter of my study focused on the rationale for studying technology use in developmental math courses at the college level. The second chapter reviews research on technology use in math courses, particularly specific programs various colleges use. In addition, research is provided concerning developmental education and technology integration in courses. Chapter 3 of this dissertation describes the quantitative approach for this study and the procedures used to gather and analyze data. Chapter 4 reports the results of the data analyses. Chapter 5 discusses the implications of the study based on the results from Chapter 4, as well as recommendations for future research.

Chapter 2: Literature Review

Introduction

This chapter describes the results of a review of the literature as to provide a background for the study. The information provides a basic framework for understanding developmental education, educational technology, and self-efficacy. This literature review begins with defining developmental education, more specifically developmental mathematics, including an overview of the history of developmental education and how it has influenced the learning college movement. In this section, I also investigated the need for developmental math and define the types of students who enroll in these courses. Next, technology integration in classrooms is discussed, with a more in-depth focus on technology integration in developmental math courses and, furthermore, how specific instructional technologies have been used. Finally, research is math self-efficacy is discussed.

Research Strategies

Literature searches were conducted using the following electronic research databases found through the Walden University library website: Academic Search Premier/Complete, The Chronicle of Higher Education, Education: A SAGE Full-Text Collection, Education Research Complete, Educational Resource Information Center (ERIC), Expanded Academic ASAP, ProQuest Dissertation and Theses, SciencDirect, and SocINDEX with Full Text. Appropriate keywords for each database were used to identify references on community college retention, technology integration, self-efficacy, and mathematics anxiety. Literature searches were also conducted through Google Scholar, dissertations, and reference lists of other articles, as well as

websites of professional organizations, and the World Wide Web. The following words were used in the electronic research databases: *remedial education, developmental education, remedial math, developmental math, higher education, underprepared students, computer-assisted instruction, computer-based instruction, computer-mediated instruction, instructional technology, educational technology, MyMathLab, Connect Math, ALEKS, McGraw-Hill, self-efficacy, mathematics, mathematics anxiety, community college, college, university, helpfulness, achievement, instructor and student retention.*

Developmental Education Defined

Developmental education grew from a need to help students become more qualified to enroll in college-level courses. Students are enrolling into college, but are not properly prepared for college-level work (Bonham & Boylan, 2012). These developmental courses act as a bridge for underprepared students to take college courses (National Association for Developmental Education, 2013). According to the National Center for Education Statistics (NCES), at degree-granting community colleges, 31% of first-time, full-time undergraduate students attained a certificate or associate's degree within 3 years (Kena et al., 2014). The retention rate varied among types of schools, with public 2-year institutions averaging 58% in 2012, private nonprofit 2-year institutions at 60%, and private for-profit 2-year institutions at 66% (Kena et al., 2014). The percentage of students who completed a certificate or degree at a 2-year public, nonprofit institution within 3 years (starting in 2009) was 20% (Kena et al., 2014). This means that most students who attend a 2-year college take longer than 150% of the normal time (2 years) it

should take to complete a degree. Similar outcomes can be seen at 4-year colleges, with less than 60% of students graduating within six years (Bettinger et al., 2013).

Once admission requirements were created at postsecondary institutions, developmental education in America took root (Arendale, 2011). The evolution of coursework in higher education saw the addition of tutors, then college preparation courses, remedial classes within college preparation programs, remedial classes integrated within institutions, developmental education, and finally developmental education with enrichment classes, activities, and programs (Arendale, 2011). Through the creation of developmental education programs, access to college became easier for disadvantaged students (Bahr, 2008).

Developmental education is mostly comprised of reading, math, and writing, and occasionally science, with the typical students being recent high school graduates who are lacking in grade-level competency (Bettinger et al., 2013). Virtually all 2-year institutions have developmental education courses (Bettinger et al., 2013). The purpose of developmental (or remedial) education is to academically assist students who are struggling in reading, writing, and/or math at the post-secondary level (Bahr, 2008; Bettinger et al., 2013; Blum, Hunter, & Schneck, 2007; Bonham & Boylan, 2012). The goal of developmental education is to increase opportunities of college success for students (Blum et al., 2007; Fong, Melguizo, Prather, 2015). With approximately one-third of first-year colleges students enrolled in developmental math courses (Adelman, 2004), these courses have a significant impact on school retention and graduation rates.

Developmental coursework does come at a price to both the institution and the students. For the 2004-2005 academic year, the national cost for developmental education in public institutions was estimated to be \$1.13 billion annually (Pretlow III & Wathington, 2011). Students pay tuition and can receive financial aid for developmental courses, but do not receive college credit for these course (Pretlow III & Wathington, 2011). When students have to take a sequence of developmental coursework, sometimes not receiving college credit for these courses, it can increase the possibility students do not finish the course because of increased financial responsibilities and time commitment (Fong et al., 2015; Holt et al., 2012). Some institutions offer developmental courses for credit that count toward the overall grade point average of the student, but do not count toward graduation requirements (Bettinger et al., 2013). About 99.4% of public, 2-year institutions offer remedial services (Snyder & Dillow, 2012). While most institutions offer developmental courses, developmental education comes at a high price for both institutions and students.

Despite low retention rates for community colleges and the costliness of the programs, some researchers have found positive correlations between developmental education programs and student success rates (Bahr, 2008, 2010; Waycaster, 2011). Completing developmental math courses early in their college career can relate to more success in subsequent courses (Wang, Wang, Wickersham, Sun, & Chan, 2017). Others have found that enrolling in developmental math courses actually decreases students' odds of successfully transferring to 4-year institution (Crisp & Delgado, 2014). Still others found that financial aid and tutoring services were more closely related to student success than developmental coursework (Bremer et al., 2013).

Developmental Mathematics

Mathematics education is important, not only for society, but also for the individual, as it offers a greater number of college and career options (US Department of Education, 2008). America's math students have been struggling. Community colleges across the nation experience low levels of student success in developmental math courses (Gerlaugh, Thompson, Boylan, & Davis, 2007). If students must first successfully complete the developmental mathematics course(s) in order to take subsequent community college and/or college courses, the outcome of these developmental math courses can greatly affect college success/graduation. Math skills at the onset of college are a powerful predictor of student success (Bremer et al., 2013). Bissell (2012) stated that less than half of the high school graduates in the United States are prepared to take college-level math courses. Furthermore, Adelman (2004) estimated that 41% of students enroll in remedial courses at some point during their college attendance. The overall goal of developmental math courses is to help prepare students for college-level math courses. Without successfully completing these precollege level courses, consequences can be significant: students are unable to complete college-level courses and, furthermore, will be unable to attain a college degree (Daugherty, Rusinko, & Griggs, 2013). Therefore, some students may be unable to attain their educational goals, because they do not succeed in these developmental math courses.

Upon entering a college or university, students are often required to take a placement test and then are placed in developmental math courses based on their scores (Blum et al., 2007). A sequence of two or more levels of remedial math courses, "starting with arithmetic and ending with beginning or intermediate algebra" are what most colleges include in their developmental

math program (Blum et al., 2007, p. 2). If a student places at the lowest level of mathematics, this equates to having to take approximately 10 credits before being able to take college-level courses (Bonham & Boylan, 2012). The longer the sequence, the greater the chance the student does not complete the sequence, and the greater the dropout rate (Asera, 2011). Usually, these types of courses do not count as college credit, but “are prerequisites for credit-bearing math courses and most degree-granting majors and programs” (Blum et al., 2007, p. 2). Therefore, students experience greater time commitment and cost for degree completion.

A goal of postsecondary institutions is to provide efficient instructional methods to underprepared students (Holt et al., 2012). While it would be assumed that developmental education would benefit all students equally, studies show that there are substantial racial differences (Bahr, 2010). Blacks and Hispanics are disadvantaged in both math achievement and experience low success rates in remedial courses (Bahr, 2010). Furthermore, historically disadvantaged students make up the largest percentage of students who begin college at the lowest remedial sequence (Bahr, 2012). While developmental math courses were created to help students succeed, it seems they have become roadblocks for successful completion of courses and degrees (Bonham & Boylan, 2012). Low-income, African American, and Hispanic students are more likely to need developmental math courses and are also less likely to succeed in these courses.

Gerlaugh, Thompson, Boylan, and Davis (2007) studied 5,000 developmental students at 116 universities and found that while retention rates in developmental math courses were 80%, only 68% earned a grade of C or better and, of those, only 58% of developmental math students

passed their first college-level math course. For students who remediate successfully in community college developmental math courses, research supports that these students show academic achievement comparable to nonremedial students (Bahr, 2008; Waycaster, 2011). In other words, there is no academic difference between students who previously took a developmental math course and those who did not take a developmental math course in their subsequent college-level math course achievement.

While many studies and publications have addressed the public view of remedial education (Bonham & Boylan, 2012; Bahr, 2010; Bahr 2012). Bachman (2013) sought to understand students' perception of remedial education. Some students reported remedial education as being a waste of time, while other shared an initial fear and embarrassment from having to take the course (Bachman, 2013). Others found that once they participated in the course, their opinions shifted to embracing a more positive experience with remedial education (Bachman, 2013). While it can be frustrating for students to be required to take developmental courses, these courses can be beneficial in aiding in the future success of their higher education degree.

Technology Integration in Classrooms

A rising emphasis on teaching with technology began in the 1990s (Mitchell, 2011). The increase in technology availability and technology use has made the integration of technology into classrooms appealing to both instructors and students (Holt et al., 2012). Technology used as an educational tool can support instructors teaching material to students in various ways. The effective use of technology can also, potentially, deepen mathematical understanding (Bos,

2009). Additionally, incorporating technology in the classroom can provide opportunities for all learners to become engaged (Raines & Clark, 2011). There are many options for integrating technology into classrooms and new options become regularly available. Technology can help increase student success in a course because it helps motivate students to become more active learners (Raines & Clark, 2011). There are six basic formats for educational technology applications: games, informational, quiz, virtual manipulatives, statistic calculation, and interactive math objects with multiple representations (Bos, 2009, p. 108). Instructional technology can be used as a supplement to regular classroom activities (Bos, 2009; Holt et al., 2012; Raines & Clark, 2011). About 40% of public 2-year colleges reported that computers were frequently used as a hands-on instructional tool for students, while approximately 44% reported computers were used occasionally (Parsad & Lewis, 2003). Hence, most community college classrooms use technology at some point over the course of a semester. How it is used varies greatly from classroom to classroom.

With conflicting outcomes of studies on whether technology improves learning, instructors can face confusion on how best to teach their class. The presence of technology in a school does not promise that students will academically improve (Hikmet, Taylor, & Davis, 2008). Furthermore, many community colleges let the instructors determine when and how they will use technology in their courses (Mitchell, 2011). During my research collection, no data was found confirming that increased money spent on technology directly results in increased student learning.

Technology Integration in Developmental Math Courses

Technology integration in math courses should be used to increase understanding of math concepts, not replace basic skill ability and knowledge (Raines & Clark, 2011). When teachers incorporate technology in mathematics courses students can become encouraged and, therefore, more actively participate (Raines & Clark, 2011). In other words, technology should be used to teach and reinforce material, not replace the student's ability to solve a problem with no technology assistance. In computer-based assignments, students can instantly see what they have done incorrectly and correct it right away, which can serve as encouragement and self-confidence builder to students because of the immediate feedback (Raines & Clark, 2011, p. 4). A goal of the instructor is to help motivate students to succeed. Raines and Clark state "...using web-based courseware for practice and instruction motivates students to do more homework, engages students in active learning, and improves retention rates" (2011, p. 4). With immediate feedback, students are able to quickly correct mistakes, instead of doing mathematical steps incorrectly, submitting work for feedback, and having to wait days or weeks until the instructor returns graded work.

Although technology is frequently used in developmental math courses, understanding students' attitudes toward technology and their math self-efficacy can help ensure that the mode of technology used in their course is most effective. Instructors must explore effective teaching and learning processes for students to actively build their knowledge and skills, especially in math (Mitchell, 2011). Furthermore, "colleges must be intentional in planning for the use of instructional technology" (Mitchell, 2011, p. 46). To succeed in math courses, students should be

able to understand an algorithm and also how and why it works, in order to build critical thinking and problem-solving skills, while also improving logic and pattern recognition. Educational technology use can potentially enhance students' understanding of the meaning behind mathematical concepts (Raines & Clark, 2011).

Much research has been done comparing the success of students in traditional lecture-based, hybrid (or blended), and online courses (Ashby, Sadera, & McNary, 2011; Spence & Usher, 2007; Trenholm, 2006, 2009). While research exists showing there is no difference between student success in traditional, hybrid, and online course study, there is also research that indicates that the learning environment does matter (Ashby et al., 2011). In Ashby et al.'s (2011) study comparison of online, blended, and face-to-face students, blended students had the least success. Once Ashby et al. adjusted for attrition rates, traditional students performed most poorly (Ashby et al., 2011). Similarly, the results of Trenholm's (2009) study on the efficacy of computer-mediated instruction for developmental math students at a community college found that of the three types of classes offered (online, computer lab, traditional lecture-based) the most successful students were enrolled in the online courses. But, the findings of Trenholm (2009) do not insinuate a clear association between learning efficacy and computer-mediation. Similar to Ashby et al. (2011), Spence and Usher (2007) found that students performed worse in online courses, but this lower performance was mostly linked to these students having lower self-efficacy.

MyMathLab

One popular choice for educational technology for developmental math courses is MyMathLab. MyMathLab is web-based learning and teaching software produced by Pearson publishers and consists of course material that is accessed online, in order to supplement the textbook. It features: “homework, student assessment, and multimedia instructional tools that enrich student learning and intends to improve retention outcomes” (Adibpour, Brown, & Calay, 2011, p. 37). In a survey of 4,540 MyMathLab and Mastering student users conducted by Pearson Education, Inc. in December 2012, 85% of students think their courses are more interactive and engaging because of the use of MyMathLab, while 88% reported it assisted in understanding the subject matter (Pearson Education, n.d.).

A study on the perceptions of MyMathLab as an online tool found that 62.7% of students agreed that MyMathLab was easy to use and 68.2% said, “it increased their understanding of the material in the mathematics course” (Law, Ng, Goh, Tay, & Sek, 2012, p. 24). Similarly, Holt et al. (2012) found MyMathLab had a positive impact on students while also supporting their comprehension. While 68.2% students reported MyMathLab increased their understanding, only 38.9% of students used the help features (Help Me Solve This, View an Example) contained within the program (Law et al., 2012). A benefit of MyMathLab is that it teaches students to construct mathematical equations properly (Adibpour et al., 2011); however, some students reported feeling that inputting equations into MyMathLab was tedious and time consuming (Holt et al., 2012). Another study on MyMathLab was unable to determine whether there was better performance on homework by students in MyMathLab versus non- MyMathLab, but it did find

students had higher passing rates in the MyMathLab group than in the non-MyMathLab group (Kodippili & Senaratne, 2008). Contrasting Kodippili and Senaratne's study, Burch and Kuo (2010) found that students using MyMathLab homework performed better on exams. This study also found that students had higher success rates in the MyMathLab group. Similarly, student success rates before and after the introduction of MyMathLab went from 48% and 53% to 83% and 85%, respectively (Adibpour et al., 2011). In a study of the perceptions of MyMathLab use in developmental math courses, Holt et al. (2012) found that while students are comfortable using MyMathLab technology, it was not the preferred method for homework assignments. Holt et al. (2012) found that students forgot to complete their homework assignments more often in MyMathLab than pen-and-paper homework. Holt et al. (2012) also found that students perceived MyMathLab as a positive component for their mathematical success. Research shows that many students say the computer application is helpful, but results of research do not indicate a clear relationship between using the computer application and increased success in math courses.

Speckler (2008) summarizes numerous case studies from various universities and colleges using MyMathLab. Results of the case studies showed that there were increases in student achievement in schools where MyMathLab was required and its use contributed significantly to the final grade. Reports also showed an increase in engagement in learning mathematics when there is "a shift in student thinking from a focus on ability to a focus on effort" (Speckler, 2008, p. 36).

Dissertation studies on the use of instructional technology, more specifically MyMathLab, in math courses have found mixed results. Nwaogu (2012) investigated the effects

of Assessment and Learning in Knowledge Spaces (ALEKS) on student online learning environment achievement at a 4-year private university and found a significant difference between pretest and posttest scores, showing that ALEKS significantly affected students' mathematics achievement. Furthermore, between the total time spent in ALEKS and the ALEKS final assessment report, Nwaogu found a non-significant and weak relationship. A conclusion of this finding is that having a strong mathematical foundation (from the beginning of the course) is paramount to student success in the course. While, overall time spent in ALEKS versus posttest scores in the math class showed no significant relationship, there was a strong positive correlation between final concept mastery scores and posttest scores.

Locklear (2012) sought to evaluate the impact of online homework on student success at a small Midwestern Christian liberal arts college over a four-year time period. Results of the study indicate that online homework improves the amount of student attempts of homework and, therefore, improves the student's class engagement. Alternative to Nwaogu (2012), results of Locklear's (2012) study indicated exam scores did not improve with the addition of online homework.

Moosavi (2009) examined students who were enrolled in math courses at a public university and compared achievement among students who were in a traditional lecture class, with those who were in a class using computer-aided instruction. In this study, those students enrolled in the traditional course performed better than the students enrolled in the MyMathLab section. Moosavi (2009) determined that instructor training played a critical role in the success of students.

There are few dissertation efforts that attempt to understand the effectiveness of MyMathLab use in developmental math courses at the community college level. The results of these studies also show mixed results. Vezmar's (2011) examined 178 students who completed all aspects of an elementary algebra course. Students' homework grades from MyMathlab were recorded, in addition to the time spent using MyMathlab, final exam grade and final course grades. The study found that students with higher MyMathLab homework grades (75% or better) saw a statistically significant increase in average final exam scores. Not surprisingly, "students' attitudes and beliefs were significantly positively correlated to both MyMathLab homework grades and final exam grades" (Vezmar, 2011, p. 31).

Chockla (2013) investigated the differences in academic improvements of developmental math students to understand the effectiveness of redesigned MyMathLab courses. By taking into consideration students' gender, instructional method, College Placement Tests, and scores in algebra, arithmetic, reading comprehension, and sentence structure, the study found that algebra and arithmetic College Placement Test scores are significant predictors of student academic improvement. Students enrolled in the MyMathLab course showed greater improvements than those students not enrolled in such a course.

Huang (2008) investigated the effects of various types of feedback from online homework on algebra problem solving skills and achievement in a remedial algebra course at an undergraduate university. The results of the study found that task-specific adapted knowledge of response feed had no significant effect on algebra problem solving skills and achievement.

Ha (2014) sought to determine if there was a relationship regarding the use of MyMathLab and community college student achievement (regarding pass, withdrawal, and future course success rate). Students in a traditional class and students enrolled in a traditional class supplemented with MyMathLab were involved in the study. Ha found that MyMathLab supplementation did not significantly contribute to students' pass, withdrawal, and future course success.

Duka (2009) investigated whether the incorporation of technology (MyMathlab) into a developmental math course would increase student success versus students enrolled in a developmental math course that did not use MyMathLab. Results show that the mean grade of students in the MyMathlab supplemented course was greater than the mean grades of the students enrolled in a course that did not supplement with MyMathLab.

Pope (2013) used student's COMPASS test scores (MyMathLab) to understand whether there was a statistical difference between students who took a learning support class in a traditional classroom setting versus a learning support class online. The study found that the online course experienced higher withdrawal rates, but there were not significant differences in scores or final grades between the traditional and online course.

Connect Math

No research was found on the Connect Math Hosted by ALEKS program directly. Connect Math is hosted by ALEKS and is primarily flash-based (McGraw-Hill, 2017). The Connect Math platform is very similar to MyMathLab. To use the program, instructors create a course and then select a primary textbook that students use for the course. By selecting a book,

the program automatically adds learning tools, instructor resources, and an exercise pool to the course. A course code is then created, which the instructor will put in the syllabus for the students to use to access the course.

In the course itself, there is a main menu of items to select: Home, Grade book, Messages, Resources, eBook, Calendar, and Help (McGraw-Hill, 2017). The main screen also has: upcoming assignments, completed assignments, and announcements. Assignments consist of: homework, quizzes, tests, and other assignments. As part of each of these assignments, the instructor can select content sources for each assignment that includes: online problems, video tutorials, external assignments, and ALEKS initial assessment.

Within the assignments are start and end date and times, and how many attempts the student has to complete and submit the assignment. Student must complete the assignment according to the directions of the instructor and can instantly find out their grades on assignments, quizzes and tests (McGraw-Hill, 2017).

Course Selection

According to Stack (2015) “Most research has been unable to control for possible selection bias given such issues as practical barriers in randomly assigning students to online vs. traditional sections of a given course...” (p. 5). Furthermore, “students who freely choose online classes may have different characteristics than students who choose traditional, live classes” (Stack, 2015, p. 5). As an example, students who choose traditional courses may be recent high school graduates vs. students who choose online courses may work full-time and have children who may choose online or computer-mediated courses. Courses may also be chosen based on

class time availability, time commitments required for course material, and location of courses (campus). Instructors can also be a reason for course selection, especially since research has indicated that various teaching styles can have an effect on student performance (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wenderoth, 2014). Students can have various reasons for choosing a certain type of class, and this cannot be controlled in the study.

Theory of Self-Efficacy

The theoretical framework for this study is the theory of self-efficacy proposed by Bandura, which is derived from Bandura's (1986, 1997) social cognitive theory. With an interest in understanding human motivation Bandura postulated that whether someone completes a task is determined by whether or not that person believes they can complete the task (1997). The theory of self-efficacy states that a person is willing to engage in an activity if they think they will be successful at completing it (Bandura, 1997). When an individual attains success in an endeavor and they can convince themselves that they have what it takes to continually succeed, they can accomplish even better things in new activities and new settings (Bandura, 1997). The four causal factors of enactive efficacy information (what it takes for one to succeed at a task) include: effort, ability, task difficulty, and chance (Bandura, 1997). According to Bandura, "Performance successes generally raise beliefs of personal efficacy; repeated performance failures lower them, particularly if the failures occur early in the course of events and do not reflect lack of effort or adverse external circumstances" (1997, p. 81). Furthermore, "those who regard themselves as highly efficacious tend to ascribe their failures to insufficient effort or situational impediments, whereas those with a low sense of efficacy view the cause of their

failures as stemming from lack of ability” (1997, p. 124). Feedback that is consistent with one’s sense of self-efficacy is perceived as being accurate, whereas performance feedback that is inconsistent with one’s self-efficacy is dismissed (Bandura, 1997). While student motivation and hard work are key components of student success, low self-efficacy in relation to coursework can hinder a students’ ability to successfully complete the coursework and eventually graduate.

Self-efficacy, a significant predictor of math success, plays an important role in developmental math courses (Spence & Usher, 2007). Low math self-efficacy can arise from past mathematics failures that may have began in primary school. To improve students’ success in math courses, years of negative emotion toward mathematics caused by frequent course failures that result in math anxiety should be addressed (Taylor, 2008). In order to achieve success in math courses, students should believe they are able to succeed. Although it is understood that mathematical self-efficacy is directly linked to math achievement and student persistence, few research studies have examined student opinion of specific instructional technology and the difference of student opinion between lecture-based and computer-mediated formats, and how that relates to math achievement.

When students do not do well in mathematics courses, they may develop low math self-efficacy, which can turn into having high math anxiety (Jameson & Fusco, 2014; Spence & Usher, 2007; Taylor, 2008). When individuals are highly anxious about math, they tend to avoid it, which lowers their competence in the material (Ashcraft, 2002). While math is important for both college degrees and life in general, many dislike and avoid math because of a combination of math anxiety and low confidence (Jameson & Fusco, 2014; Taylor, 2008). Math anxiety is “a

feeling of tension, apprehension, or fear that interferes with math performance” (Ashcraft, 2002, p. 181). Research on how and why students develop math anxiety suggest that self-efficacy and self-concept play an important role (Jameson & Fusco, 2014). Low math self-efficacy can lead to failure in students’ college endeavors.

A study with pre-service teachers enrolled in a mathematics content course found that mathematics belief had a statistically significant effect on math teaching efficacy and math self-efficacy (Briley, 2012). Moreover, those pre-service teachers who reported stronger beliefs in their teaching capabilities were more likely to have confidence in solving math problems. A study on math self-efficacy for traditional versus online students found that age emerged as a significant predictor of engagement in the mathematics course (Spence & Usher, 2007). This may suggest that older students are more likely to have the structure and discipline to complete the tasks assigned in the course and stay more engaged. Gupta, Harris, Carrier and Caron (2006) reported that among the most valuable predictors of success in entry-level undergraduate math courses was a more positive attitude toward math as well as higher age. Similarly, Markle (2017) found that math self-concept is necessary for success in the math course.

Passing developmental math courses is extremely important for students placing into these courses at the college levels. Students will only be able to continue their journey through higher education by completing these basic courses. To guarantee students are receiving quality education and are able to graduate, it is important to understand their perceptions of technology and how their self-efficacy is affected by the use of educational technology. The theory of self-efficacy will inform this study by showing how Connect Math affects student self-efficacy in

lecture-based versus computer-mediated formats. The theory of self-efficacy will also inform the study by helping to explain student opinion of the Connect Math technology. The study will add to the existing knowledge as it examines the effects Connect Math has on student self-efficacy as a result of exposure to Connect Math.

Summary

This dissertation is among the few to study whether there is a connection between math self-efficacy and math achievement of students enrolled traditional lecture-based and computer-mediated formats of developmental math courses at the university level and how it relates to course grades as a result of exposure to Connect Math. Many previous studies focus on comparing online, hybrid, and traditional education or students' perceptions of instructional technology. Other studies focus on how students use specific instructional technology (by studying how often they log in, how long they stay logged in, and what features they use). Studies focusing on achievement and engagement of students, as a result of using instructional technologies have mixed results. Since there have been previous studies on math self-efficacy, research instruments and tools that have previously been developed will be used in this study.

The purpose of this study was to examine the relationships between math self-efficacy and math achievement in students in developmental courses that utilize Connect Math. To understand the effectiveness of Connect Math, a literature review was conducted which first focused on college student retention in general, then community college retention, and then, more specifically, retention in developmental math courses. Following was a description of developmental math programs at community colleges. The focus then turned to instructional

technology terminology and technology use in the classrooms, in general, and in math classrooms, more specifically. Lastly, motivation and self-efficacy theory from Bandura (1997) were discussed.

There exist a few gaps in the literature pertaining to Connect Math use, which need to be addressed. This study addressed some of these gaps, specifically student opinion of the program, as well as their perceived usefulness of the program. Chapter 3 describes the methodology used to examine the relationships between math self-efficacy and math achievement in students in computer-mediated and traditional lecture-based developmental courses that utilize Connect Math. Chapter 4 discusses the results of the data analyses. Chapter 5 describes the implications based on the results from Chapter 4, along with recommendations for future research.

Chapter 3: Research Method

Introduction

The purpose of this quantitative study was to examine the relationships between math self-efficacy and math achievement of students in computer-mediated and traditional lecture-based developmental courses that utilize Connect Math. Five research questions and hypotheses were formed from this purpose. This chapter delineates the methodology for conducting this study, as well as the rationale for each decision made by the researcher.

Research Design and Rationale

Since this study attempted to provide a numeric description of attitudes of a population by studying a sample of the population, and statistically interpreting results, quantitative research was chosen (Creswell, 2009). This was a quasi-experimental study because it tested the impact of a treatment (Connect Math) on an outcome (relationship between math self-efficacy and math achievement), but did not have random assignment (Creswell, 2009). First, the relationship between math self-efficacy and math achievement in computer-mediated and traditional lecture-based courses (which use Connect Math) was examined; second, the relationship between student opinions of Connect Math and math achievement were examined. Furthermore, since the students were dependent upon the instructors (i.e., a nested design), instructor was included as a covariate.

Research Questions

This quantitative study attempted to discover, decode, and explain the following central question: What is the relationship between math self-efficacy and math achievement in students

in computer-mediated and traditional lecture-based developmental courses that utilize Connect Math? The specific research questions addressing this overarching research question, and the associated hypotheses, were as follows:

1. Is there a significant difference between math self-efficacy in students enrolled in courses using Connect Math in computer-mediated math courses and traditional lecture-based developmental math courses?

H₀1: Math self-efficacy was lower than or no different for students enrolled in computer-mediated courses compared to traditional lecture-based courses.

H₁1: Math self-efficacy was greater among students enrolled in computer-mediated courses compared to traditional lecture-based courses.

2. Was there a difference in opinion (i.e., attitude, perspective) of Connect Math based on delivery method (computer-mediated vs. traditional lecture-based)?

H₀2: There was no difference in opinion of Connect Math based on delivery method (computer-mediated vs. traditional lecture-based).

H₁2: A negative opinion of Connect Math was more prevalent among students who were in traditional lecture-based courses.

3. Was there a significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses?

H₀₃: There was no significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses.

H₁₃: There was a significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses, with computer-mediated students having higher achievement than traditional lecture-based students.

4. Did opinion (i.e., attitude, perspective) of Connect Math relate to math achievement among students in developmental math courses and did this relationship differ by class delivery mode?

H₀₄: There was no relationship between opinion and math achievement and this relationship did not differ by course delivery type.

H_{1a4}: A negative opinion was related to lower achievement, and the relationship was stronger in traditional courses compared to computer-mediated courses.

H_{1b4}: Positive opinion was related to greater achievement, and the relationship was stronger in computer-mediated courses compared to traditional courses.

5. Did math self-efficacy mediate the relationship between class delivery mode and math achievement?

H₀₅: Math self-efficacy did not mediate the relationship between class delivery mode and math achievement.

*H*₁₅: Math self-efficacy mediated the relationship between class delivery mode and math achievement. Specifically, there was a direct effect of class delivery mode on math achievement (*H*₁₃) such that computer-mediated instruction with Connect Math predicted greater math achievement than traditional course delivery.

Computer-mediated instruction predicted higher self-efficacy, and higher self-efficacy predicted greater achievement. There was full or partial mediation such that self-efficacy explained the relationship between class delivery mode and math achievement.

Methodology

Description of Population

The study was conducted at California State Polytechnic University, Pomona (CPP) located in Pomona, California. As of 2017, CPP institutional statistics reports an undergraduate student enrollment of approximately 22,149 students with an undergraduate average class size of 35 (Cal Poly Pomona, (n.d.)). I collected a sample of 157 developmental math students who were enrolled in developmental math courses (either beginning or intermediate algebra). As observed in the following section on power analysis, I initially targeted a minimum sample of 176 students to achieve a 5% chance of Type I error and a 95% confidence level. To facilitate participant recruitment, mass email was sent to instructors who taught developmental math students. Approval to contact the instructors was obtained through the CPP Institutional Review Board (IRB) (Protocol Number: Walden 10-25-16-0300229).

CPP Developmental Math Program

CPP started a remediation program in 1997 (Cal Poly Pomona, 2015). Students are exempt from the remediation program if one of the following applies: a score 550 or greater on the SAT, a score of 23 or greater on the ACT, 3 or greater score on the AP Calculus or AP Statistic test, or an Entry Level Mathematics (ELM) exam score of 50 or greater (Cal Poly Pomona, 2015). According to institutional statistics there were approximately 420 students enrolled in developmental math in the fall quarter 2016 (September – December). Over 4,000 students take math courses each quarter, including math courses for precredentialed teachers (Cal Poly, 2017). Developmental math courses include beginning and intermediate algebra. Students are required to complete all developmental courses by the end of the summer of their first year of college (Cal Poly, n.d.).

Sampling and Sampling Procedure

The sample for the study included students enrolled in developmental math courses at CPP, and aged 18 and over. This study was a quasi-experimental, nonequivalent control group, posttest-only design. Students completed a questionnaire assessing their math self-efficacy and student opinions of Connect Math. Control variables included student gender, age, and ethnicity, as well as the instructor's name. The majority of students were California residents, and the sample included both traditional and nontraditional students. Students were placed into the developmental course based on placement test scores, while others were placed based on prior coursework.

Since this study used the available students in a class, convenience sampling was used (Frankfort-Nachmias, & Nachmias, 2008). As the sample was not selected based from what appeared to be representative of the population, purposive sampling was not chosen (Frankfort-Nachmias, & Nachmias, 2008). For this study, it was unnecessary to have a sample population as similar as possible to the entire population so quota sampling was not chosen (Frankfort-Nachmias, & Nachmias, 2008). Simple random sampling, stratified sampling, cluster sampling, and systematic sampling were not chosen because a small sample was not be used as representative of the whole (Frankfort-Nachmias, & Nachmias, 2008). The sample size for this study included 157 students.

Procedures for Recruitment, Participation, and Data Collection

A quasi-experimental quantitative design was used to analyze the relationship between student self-efficacy and math achievement of students in lecture-based and computer-mediated developmental math courses that utilize Connect Math. The independent variable in this study was the instructional delivery method (lecture-based and computer-mediated). Control variables included student gender, age, and ethnicity, as well as the name of their instructor. The dependent variables included math self-efficacy, students' opinion toward Connect Math, and math achievement. Final course grades served as the measure of math achievement for this study. The participants' self-selected the developmental math course (computer-mediated or traditional lecture-based) they placed into. The sample consisted of nine classes that were either beginning or intermediate algebra, with five courses being computer-mediated and four courses being traditional lecture-based. There were 157 students from CPP who participated in the study. The

selected sample includes students who tested into the developmental math course or were placed according to their prior coursework. Approximately 300 students were asked to participate in the study to account for students who would elect to not participate in the study and ensure a sufficient sized sample. Students self-selected into the particular developmental math courses (computer-mediated or traditional lecture-based) and volunteered for the study, therefore a convenience sample was used.

This study used ANCOVA to analyze the differences among group means and variation between groups, controlling for demographics including gender, age, and ethnicity and to analyze Research Questions 1, 2, and 3. Hierarchical linear regression was used to answer Question 4, with class type as dichotomous predictor and opinion as continuous predictor with math achievement as outcome. A mediational model using bootstrapping run with the PROCESS macro (Hayes, 2012) was used to test Hypothesis 5. With a Type I error rate of 5% and a 95% confidence level, the recommend sample size of this study was 176 using the program *G*Power* (Faul, Erdfelder, Lang, & Buchner, 2007). Because the study used the available students in a class, convenience sampling was used (Frankfort-Nachmias, & Nachmias, 2008). Oversampling was used to ensure an adequate number of students participated in the study.

Participants were given an informed consent form before they completed the study. Participants were recruited via an invitation by their instructors to complete the survey, either online or via paper and pencil, regarding their self-efficacy and opinion of Connect Math. Instructors were asked to allow 15-20 minutes at the beginning of one class session to complete the study, or to provide the students the link to complete the study outside of class time. Students

then completed the survey online either via Survey Monkey or pencil and paper. The online survey results were available immediately after students completed the survey. The paper and pencil surveys were mailed to the researcher. Finally, instructors were asked to submit final grades to the researcher.

Instrumentation and Operationalization of Constructs

A survey instrument was used to measure developmental math students' math self-efficacy towards the end of a math quarter. A survey design studies a sample population and can provide a numeric description of attitudes (Creswell, 2009). An online questionnaire was most appropriate for this kind of research because it has a low cost and is conducted faster than mail questionnaires (Frankfort-Nachmias, & Nachmias, 2008). The online questionnaires were used by the computer-mediated courses while the traditional lecture-based courses used the paper and pencil questionnaires. The questionnaire included closed-ended questions with a 5-point Likert scale response format. The Likert scale is a research method designed to measure attitudes (Frankfort-Nachmias, & Nachmias, 2008). A pre-existing questionnaire on self-efficacy was given over the Internet via the website [surveymonkey.com](http://www.surveymonkey.com) (with permission from the original authors), as well as provided via paper printed out. The advantages of this method of online surveying include rapid scanning of information collected and having low to no cost (Ahern, 2005; Frankfort-Nachmias, & Nachmias, 2008). Data from both the end-of-course math assessment and the survey were analyzed to see how responses related with one another.

Self-efficacy. To assess math self-efficacy, the Abbreviated Version of the Mathematics Anxiety Rating Scale (A-MARS) was used (Richardson & Suinn, 2012). Within this scale,

participants rated their math self-efficacy relating to various scenarios commonly experienced during a math course. There were 23 items, rated on a 5-point Likert-format, 1 (*Not at all*) to 5 (*Very much*). Student responded to survey questions to indicate their level of anxiety in certain situations involving math courses. The survey responses were Likert-type with a greater score reflecting less self-efficacy involving various math scenarios. Cronbach's alpha for the 23 math self-efficacy items was .963, which indicates high reliability. No questions were recoded because no questions contained negative wording (See Appendix A).

Math Achievement. To measure students' performance in their math course, instructors submitted final end-of-semester letter grades (on a 4.0 scale) to the researcher.

Student Opinion. To measure students' opinion of Connect Math, or how much they liked using the program, a pre-existing questionnaire, MAT 131MyMathLab Survey, was used (Holt et al., 2012). Nine items, rated on a 5-point Likert-format, 1 (*Strongly disagree*) to 5 (*Strongly agree*), were used. Cronbach's alpha for the 9 student opinion items was .896, which indicates high reliability. No questions were recoded because no questions contained negative wording.

Perceived Helpfulness of Connect Math. To measure students' opinion of how helpful Connect Math was MAT 131 MyMathLab Survey was also used (Holt et al., 2012). Fifteen items, rated on a 5-point Likert-format, 1 (*I did not use this*) to 5 (*Very helpful*), were used. Cronbach's alpha for the 15 student opinion items was .94, which indicates high reliability. No questions were recoded because no questions contained negative wording.

Threats to Validity

Ensuring adequate sampling procedures, using appropriate statistical tests, and using reliable measurement procedures all reduced threats to validity in this study. Threats to external validity were reduced by not including experimental variables, nor including any treatment interferences. Using only one survey, introduced during one course time for participants in the study to complete, reduced threats to internal validity. Threats to the statistical conclusion were avoided by only making clear conclusions to the research from results from the data. No conclusions on the relationships between data were stated when results did not indicate a clear relationship.

Ethical Procedures

The roles of the researcher in this study was to send out and collect surveys, input data into SPSS, and analyze the results to answer the research questions. I had no current or past relationship with any students, instructors, or staff at the college. Biases were minimized by only using exact responses as recorded on the survey instruments.

Once data were collected and statistical analyses completed, the official findings were mailed to the participant institution. I plan to submit proposals to professional organizations of which I am a member for articles in professional journals or poster sessions. In this way, others will be able to view a study on math self-efficacy and math achievement and the use of Connect Math. This is particularly important for instructors of developmental math courses, so that they can find ways to help students increase their math self-efficacy.

Summary

This study used a quasi-experimental quantitative design to analyze the relationship between student self-efficacy and math achievement among students in lecture-based and computer-mediated developmental math courses that utilize Connect Math in Pomona, California. Computer-mediated courses that use Connect Math were compared to traditional lecture-based courses that use Connect Math. The source of quantitative data was the survey results from students participating in the course.

In Chapter 4, I summarize details pertaining to data collection including time frame, recruitment, and how final sample size and characteristics generated acceptable representativeness. In addition, I present a comprehensive overview of the results of this study, which include a presentation of descriptive statistics, statistical analyses, and tables that provide improved clarity to the interpretation of findings. Overall, I explain how student opinion and self-efficacy relate to math achievement in developmental math courses. Chapter 5 describes the implications based on the results from Chapter 4, along with recommendations for future research.

Chapter 4: Results

Introduction

This chapter provides a general overview of the study, followed by descriptive statistics of the participants in the study. Comparisons between the two types of courses (computer-mediated and traditional lecture-based) were used to consider any differences that may exist to strengthen the analyses of the research questions. Next, the results of the data analyses of each of the five research questions are discussed. The responses for each survey construct are linked to the related research question. For all analyses, the alpha level was set at .05, two-tailed. The chapter concludes with a summary of the results.

The purpose of this study was to examine the relationships between math self-efficacy and math achievement among students in computer-mediated and traditional lecture-based developmental courses that utilized Connect Math. The study explored the differences in student opinion of Connect Math, math achievement and math self-efficacy and the difference between computer-mediated and traditional lecture-based courses. Students from each type of course were enrolled in developmental math courses at CPP during the same fall 2016 term.

The computer-mediated students were enrolled in developmental math courses that had reduced traditional lecture-based class time and a greater emphasis on Connect Math to help facilitate learning. When computer-mediated classes met, it was in a computer lab. Traditional lecture-based courses met more frequently than computer-mediated students, and lectures took place in a traditional classroom setting (with no computer access).

Since students self-selected into the types of courses they were in, convenience sampling was used. 157 students total participated in the study- including both traditional lecture-based courses ($n = 81$) and computer-mediated courses ($n = 76$), all of who used the educational technology platform Connect Math as part of their coursework.

Beyond the informed consent, two existing surveys were combined into one survey and was given out via Survey Monkey (for computer-mediated students) and printed out for traditional lecture-based students and handed out during class time (see Appendix A). The data collection tools used to gather information of student opinion of Connect Math was Math 131 MyMathLab Survey. Permission to use the survey is found in Appendix E. The survey was altered to name Connect Math in place of MyMathLab since CPP currently uses Connect Math as their math instructional tool. The data collection tool used to gather information of student math self-efficacy was the abbreviated version of the Mathematics Anxiety Rating Scale (A-MARS). Permission to use the survey is found in Appendix F. One comment box was added to the survey so that students were also able to add any additional comments they had regarding the Connect Math program that was not included as part of the survey. Demographic information was collected at the end of the survey: student sex, age, race/ethnicity, and last mathematics course completed in high school. Finally, students' course completion grade was collected at the end of their course from their instructors. To organize and interpret data collected from the students, results from the survey and students' final grades were inputted into SPSS Version 23.

In the data analysis of the responses to the closed-survey questions, response means using the students' responses of the Likert-type survey questions were calculated. In the tables for each research question, percentages for each response category/survey item are presented.

Data Collection

Time Frame, Actual Recruitment, and Response Rates

Students were included in the study if they were enrolled in a developmental math course during Fall 2016 and their instructor volunteered to participate in the study. It was necessary for the instructor to volunteer for the study because instructors had to hand out the surveys (traditional lecture-based students) or send out the links to the survey (computer-mediated students) and they also had to forward final grades of the students. Emails to request participation were sent out on November 11, 2016. Links and printed copies of the survey were provided to instructors by November 20, 2016. Students in traditional lecture-based courses were given one class period to complete the survey. Students in computer-mediated courses were either given a class period to complete the survey on the computer or they could complete the survey during their own time at home. Requests for final course grades were emailed on December 15, 2016. Grades were submitted to the researcher by January 4, 2017. Participants accessed the survey online via Survey Monkey between November 2016 and December 2016. Based on the power analysis for the sample size previously discussed in Chapter 3, I initially targeted a total sample size of 176; however, I was only able to recruit 157 students. Once I received the final data in January 2017, data collection efforts were discontinued. A total of nine classes participated in the study, which included five computer-mediated and four traditional

lecture-based courses. The nine courses included 157 students who elected to participate in the study (76 computer-mediated students and 81 traditional lecture-based students).

Problems with data collection included one instructor who did not submit final grades for their 10 students who participated in the study. Also, 34 students did not feel comfortable providing their student ID number in order for the researcher to receive final course grades. While these 44 students still participated in sharing their opinion of Connect Math, their math achievement (i.e., final grade in the course) could not be compared to their opinion in order to answer Research Questions 2b, 3, and 4. Lastly, some students did not share all demographic information (age, gender, race/ethnicity). Some students shared age and gender but not race, or they shared their race and age but not gender, etc.

Descriptive Statistics for Demographic Characteristics

Table 1 shows descriptive statistics for the 157 students who participated in the study. The sample as a whole was relatively young ($M = 18.16$ years, $SD = .491$). Students who were in a computer-mediated developmental math course comprised 48.4% of the sample, leaving 51.6% of the sample from students who were in a traditional developmental math course. One hundred two females (65%) and 50 males (31.8%) participated in the study and 3.2% declined to report their gender. Finally, the ethnic distribution showed Hispanic/Latino participants to have comprised 65.6% of the sample.

Table 1

Demographics for Overall Sample (N = 157)

Variable	<i>n</i>	%
Age		
18	132	84.1
19	16	10.2
20	2	1.3
22	1	.6
Declined to respond	6	3.8
Class type		
Computer-mediated	76	48.4
Traditional	81	51.6
Sex		
Female	102	65
Male	50	31.8
Declined	5	3.2
Race/Ethnicity		
Asian	17	10.8
Biracial	2	1.3
Black/African American	8	5.1
Hispanic/Latino	103	65.6
White/Caucasian	14	8.9
Other	3	1.9
Declined	10	6.4

Results

Research Question 1

In Research Question 1, I examined whether there was a significant difference between math self-efficacy in students enrolled in courses using Connect Math in computer-mediated math courses and traditional lecture-based developmental math courses. This research question addressed the anxiety students felt in relation to different aspects of math courses, using anxiety as an indication of student's self-efficacy. Block 13 in the survey investigated this aspect of the study and included 23 questions. This portion of the survey stemmed from the A-MARS survey. A one-way ANCOVA was conducted to test for a statistically significant difference between class type on student self-efficacy controlling for instructor, race/ethnicity, gender, and age. Mean results from the students' self-efficacy responses appear in Table 2. Results indicated the control variables were not significant predictors of self-efficacy including instructor ($p = .302$), race/ethnicity ($p = .075$), and gender ($p = .581$). There was, however, a significant relationship between age and math self-efficacy $F(1, 140) = 4.23, p = .042$, with an effect size of $\eta_p^2 = .029$. There was a positive correlation between age and math self-efficacy: as age increased, math self-efficacy increased and conversely, as age decreased, math self-efficacy decreased $r(138) = .252, p < .05$. Lastly, there was no statistically significant relationship between class type and math self-efficacy at the .05 level, $p = .0807$. The analysis of this research question indicated that the null Hypothesis 1 was not rejected and, therefore, math self-efficacy was either lower than or no different for students enrolled in computer-mediated courses compared to traditional lecture-based courses.

Since there was no significant relationship between math self-efficacy and class type with all of the questions from Block 13 of the survey, an ANCOVA was run on each individual survey question to see if there was a relationship between class type and math self-efficacy for each specific question. Of the 23 questions in block 13 of the survey reflecting level of math anxiety, only “Picking up a math textbook to begin working on a homework assignment” (Question 4) showed a significant relationship with class type $F(1, 140) = 5.79, p = .017$, with an effect size of $\eta_p^2 = .040$. The mean response to this question was 2.28 (std. error = 1.3) for computer-mediated students and 2.68 (std. error = 1.31) for traditional lecture-based students. The finding is exploratory since only one item of the self-efficacy survey was used. Using only one item out of the scale makes reliability and validity questionable, but if reliability and validity were good for this item, the results would support hypothesis one in that computer-mediated students reported slightly less anxiety, or higher math self-efficacy, than traditional lecture-based students. All other questions were not significant. This finding suggests there is very limited support for Hypothesis 1 and therefore results for this research question indicate the null Hypothesis 1 was not rejected and there was no difference in math self-efficacy for students enrolled in computer-mediated courses compared to traditional lecture-based courses.

Table 2

Math Self-Efficacy Responses

Question	<i>M</i> <i>Computer</i> <i>mediated</i>	<i>SD</i> <i>Computer</i> <i>mediated</i>	<i>M</i> <i>Lecture</i>	<i>SD</i> <i>Lecture</i>
Studying for a math test	3.29	1.18	3.44	1.18
Taking the math section of the college entrance exam	3.7	1.12	3.62	1.21
Taking an exam (quiz) in a math course	3.32	1.22	3.58	1.17
Picking up a math textbook to begin working on a homework assignment	2.28	1.30	2.68	1.31
Being given homework assignments of many difficult problems that are due the next class meeting	3.12	1.29	3.41	1.35
Thinking about an upcoming math test 1 week before	3.08	1.41	3.42	1.31
Thinking about an upcoming math test 1 day before	3.54	1.33	3.89	1.20
Thinking about an upcoming math test 1 hour before	3.75	1.21	3.95	1.21
Realizing you have to take a certain number of math classes to fulfill requirements	3.50	1.15	3.80	1.30
Picking up a math textbook to begin a difficult reading assignment	2.91	1.30	2.95	1.44
Opening a math or statistics book and seeing a page full of problems	3.00	1.32	3.35	1.39
Getting ready to study for a math test	3.12	1.25	3.26	1.33
Being given a “pop” quiz	3.59	1.21	3.59	1.40

Question	<i>M</i> <i>Computer</i> <i>mediated</i>	<i>SD</i> <i>Computer</i> <i>mediated</i>	<i>M</i> <i>Lecture</i>	<i>SD</i> <i>Lecture</i>
Reading a cash register receipt after your purchase	2.40	1.42	2.22	1.40
Being given a set of numerical problems involving addition to solve on paper	2.54	1.38	2.27	1.32
Being given a set of subtraction problems to solve	2.39	1.42	2.07	1.33
Being given a set of multiplication problems to solve	2.47	1.48	2.07	1.32
Being given a set of division problems to solve	2.45	1.42	2.19	1.30
Buying a math textbook	2.53	1.45	2.63	1.58
Watching the teacher work on an algebraic equation on the blackboard	2.49	1.47	2.20	1.32
Signing up for a math course	2.89	1.31	2.64	1.42
Listening to another student explain a math formula	2.63	1.35	2.44	1.30
Walking into a math class	2.39	1.43	2.58	1.58

Bolded item was found to be significant

(table continues)

Research Question 2

In Research Question 2, I examined whether there was a difference in opinion and perceived helpfulness of Connect Math based on delivery method (computer-mediated vs. traditional lecture-based). To aid in answering this question and to provide students the opportunity to give more personal feedback, a comment box was added so that students were able to fill in their thoughts on Connect Math. Of those surveyed, 47 students left written comments: 17 from computer-mediated courses and 30 from traditional lecture-based courses. Question 11 of the survey contained the comment box. Those comments have been included below. Comments received by students were left unedited.

A one-way ANCOVA was conducted to test for a statistically significant difference between class type on students' perceived helpfulness of Connect Math controlling for instructor, race/ethnicity, gender, and age. Results from the survey questions regarding the helpfulness of Connect Math indicated there was a significant relationship between class type and student's perceived helpfulness of the Connect Math program, $F(1, 140) = 8.301, p = .005$. The mean response to this question block was 4.56 (std. error = .072) for computer-mediated students and 4.23 (std. error = .074) for traditional lecture-based students. There was a significant relationship between class type and perceived helpfulness of Connect Math, with computer-mediated students reporting higher perceived helpfulness of Connect Math than traditional lecture-based students.

A one-way ANCOVA was conducted to test for a statistically significant difference between class type on student opinion of Connect Math controlling for instructor, race/ethnicity,

gender, and age. Results from the survey questions regarding the opinion of Connect Math indicated instructor did not predict student's opinion of the Connect Math program $p = .168$. Results also indicated there was no significant relationship between race/ethnicity and student's opinion of the Connect Math program $p = .548$, as well as between gender and student's opinion of the Connect Math program $p = .759$. There was no significant relationship between age and student's opinion of the Connect Math program $p = .669$. Lastly, there was no significant relationship between class type and student's opinion of the Connect Math program $p = .158$. Results for this research question indicate the null Hypothesis 2 was not rejected and there was no difference in opinion of Connect Math based on delivery mode.

Question 11 on the survey was a comment box. Students were able to enter as long of comment as they wanted. Favorable comments regarding Connect Math included any statements that were favorable to the program. Of the 47 students who left comments approximately 15% of students gave favorable comments (4% from computer-mediated students and approximately 11% from traditional lecture-based students). Several students mentioned enjoying the examples provided to help them complete their work. They also made general statements regarding their favorability of the program. Students' comments are listed below.

Student 39: It was really easy to use and extremely helpful with the option of showing an example. (Computer-mediated)

Student 61: Connect Math's homework assignment examples were great. I understand math more because of it. (Computer-mediated)

Student 88: Connect math was very helpful. (Traditional)

Student 89: Very useful! (Traditional)

Student 122: It is a good way to do your homework. (Traditional)

Student 125: I liked using connect math. (Traditional)

Student 145: It helped me understand better by the examples given. (Traditional)

Unfavorable comments regarding Connect Math included any statements that were unfavorable to the program. Of the 47 students who left comments 68% of students gave unfavorable comments of the program (approximately 25% from computer-mediated students and approximately 43% from traditional lecture-based students). Students mostly mentioned their dislike for the program requiring specific answers for homework and tests (not accepting other forms of the answer). Also mentioned was their frustration with entering long answers. Additionally, several students mentioned it was not user-friendly, was too time consuming, and also too expensive. Students' comments are listed below.

Student 5: The program really needs improvement on the homework portions. There were multiple problems when entering answers. The teacher also had to go in and fix some parts of the assignment or complain to the website an unexceptionable amount of times. (Computer-mediated)

Student 6: It made it difficult to do tests as on a test I couldn't just peek at an example of how to solve the problem. (Computer-mediated)

Student 8: While doing my homework, I have found a few errors that my professor has said to do during a lecture which Connect Math told me it was wrong. Sometimes the program says my answer is wrong when I put in the correct answer. (Computer-mediated)

Student 9: Sometimes it would be extremely difficult to use because they wanted specific answers. (Computer-mediated)

Student 21: Connect Math is not better than doing it on paper it was very frustrating putting in answers. (Computer-mediated)

Student 45: Inputting long answers was time-consuming and not very user-friendly. (Computer-mediated)

Student 53: I really didn't like using this program because it was hard to input the answers, and because everything had to be perfect. I would have preferred to use the textbook and do problems out of there. (Computer-mediated)

Student 59: Connect math was 2 confusing to use. Sometimes, when the program said the answer was wrong, it was the same as the correct answer. (Computer-mediated)

Student 64: Sometimes, I would go to press show example and I would press the solve button and after doing a lot of work, boy it sucks to start over. (Computer-mediated)

Student 70: Needs to be more user friendly. (Computer-mediated)

Student 71: Takes more time to complete homework. (Computer-mediated)

Student 74: Connect Math lags a lot and it does not allow you to put in answers in a different way. You must exactly insert the answer the way Connect Math is programmed. (Computer-mediated)

Student 78: It was so time consuming. (Traditional)

Student 79: Program was not needed. (Traditional)

Student 80: Not recommended to use for a class. (Traditional)

Student 81: Not recommended. (Traditional)

Student 93: It's complicated to use. (Traditional)

Student 94: So not user friendly. (Traditional)

Student 97: It sucked. (Traditional)

Student 109: Way to long of a process to do easy math. (Traditional)

Student 111: It's hard to type in the exact correct format of the answer and then after 3 tries getting it wrong. (Traditional)

Student 113: I like to do math homework on paper, with pencil. (Traditional)

Student 126: Very time consuming. (Traditional)

Student 129: Typing in the answer should be a quicker way of doing it. (Traditional)

Student 131: It needs to be specific on how it wants a solution inserted. (Traditional)

Student 132: It would mark my answers wrong when in the wrong format but in reality the answers were correct. (Traditional)

Student 138: Personally, I strongly dislike Connect Math. It is frustrating to enter the answers and it is too technical. I prefer pencil and paper. (Traditional)

Student 140: It wasn't the best when getting it wrong and having to redo a WHOLE NEW PROBLEM when your just getting the hang of the other one. (Traditional)

Student 146: Not user friendly at all. Whole problem is wrong if you accidentally type something wrong. You could have a small error and it wont tell you what part is wrong. (Traditional)

Student 148: Expensive. (Traditional)

Student 154: It was hard to input answers. Less motivational! (Traditional)

Student 157: Connect Math is horrible. (Traditional)

Mixed comments regarding Connect Math included comments that had both positive and negative reviews of the program. Of the students 47 students who left comments 17% of students had mixed reviews of the program (6% of students from computer-mediated courses and 11% of students from traditional lecture-based courses). These students mentioned that they enjoyed using features of the program like “show example” but disliked entering long answers, only accepting exact answers, and glitches in the program. Students’ comments are listed below.

Student 1: Connect math has been a great tool to get a better understanding of what I'm doing but one drawback is sometimes when you input an answer and it marks it wrong but the answer that you imputed matches the correct answer. (Computer-mediated)

Student 27: slow and hard to use but good for teaching and difficult for those who cant afford it. (Computer-mediated)

Student 73: Connect Math was actually really helpful!! Sometimes it was a pain when you misplace a bracket or parenthesis, but overall it was good! It was easy to use. (Computer-mediated)

Student 86: It was time consuming to input the answer. Not the best but loved "show my example". (Traditional)

Student 96: Connect Math is really slow. It freezes and also I don't like how you need to write the answer the only thing I liked about Connect Math was that it has useful examples. (Traditional)

Student 98: It was a struggle but I got used to it. (Traditional)

Student 101: Overall very helpful, but a lot of technical errors. For example putting in an answer 3 times but it kept saying it was wrong when it was actually right. Also not being able to put a complete answer in answer box. (Traditional)

Student 105: Although Connect Math provides instant feedback, it still took a long time to input answers and was very frustrating. (Traditional)

Considering the survey results for helpfulness and students' open ended responses, it seems that students in the computer-mediated class generally found Connect Math more helpful and provided more positive comments and fewer negative or mixed comments than students in the traditional lecture course.

Research Question 3

In Research Question 3, I examined whether there was a significant difference between math achievement (i.e., final grades) in students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses. The purpose of this question was to see if a particular class had a better outcome of grades (i.e., were there significantly higher grades in one type of class). ANCOVA was conducted to test for a statistically significant difference between math achievement in students

enrolled in courses using Connect Math in computer-mediated courses and traditional lecture-based courses, controlling for instructor, race/ethnicity, gender, and age. Not all students were comfortable providing their student ID number, which was an essential part in knowing their final grades in the course. Response rate for computer-mediated students' ID number was much higher than traditional lecture-based students. Of the 76 computer-mediated students, 74 provided their ID number. Of the 80 traditional lecture-based students, 39 provided their ID number. Table 4 shows the number of students who received each letter grade in the different types of courses. Results from the survey indicated that instructor did not predict GPA at the alpha .05 level ($p = .108$). Results also indicated there was no significant relationship between race/ethnicity and GPA, $p = .536$, as well as between gender and GPA, $p = .971$. There was no significant relationship between age and GPA, $p = .536$. Lastly, there was no significant relationship between class type and GPA at the .05 level; however, there was a marginally significant trend, $F(1, 106) = 2.575, p = .120, \eta_p^2 = .023$. The mean GPA for computer-mediated students was 2.026 (std. error = .125) and 1.668 (std. error = .178) for traditional lecture-based students. There was a marginal effect of class type on GPA of Connect Math, with computer-mediated students having a slightly higher GPA than traditional lecture-based students. This provides some support for Hypothesis 4. Without any significance found this results are just random data variances. Results for this research question indicate the null Hypothesis 3 was not rejected and, therefore, no significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses.

Research Question 4

In Research Question 4, I examined whether opinion (i.e., attitude, perspective, perceived helpfulness) of Connect Math related to math achievement in students in developmental math courses and whether this relationship differed by class delivery mode. The questions pertaining to this subject included questions 2-10 in the survey, as well as block 12 in the survey. A hierarchical regression analysis was conducted to test for a statistically significant interaction between class delivery mode and student opinion of Connect Math on math achievement, controlling for instructor, race/ethnicity, gender, and age. Student's individual GPA in the developmental math course served as the measurement of math achievement.

Of the students who responded, 112 were included in the sample for this test. No significant interactions were found between class delivery mode and student achievement, using student opinion of Connect Math as a continuous predictor variable, $p = .514$. One of the control variables, Instructor, significantly predicted student opinion of Connect Math $t(104) = 2.302$, $p = .023$. However, since this relationship was not hypothesized, and the identity of the instructors is confidential, no further analyses were conducted. Results for this research question indicate the null Hypothesis 4 was not rejected and, therefore, there was no relationship between opinion and math achievement and this relationship did not differ by course delivery type.

Table 3

Overall Means of Student Opinion of Connect Math

Question	<i>M</i>	<i>SD</i>
Before taking this course I was comfortable using a computer	4.24	.96
In general, I found the Connect Math program to be user-friendly	3.48	1.20
In general, I liked doing my homework on Connect Math instead of doing paper and pencil homework.	2.99	1.41
I understand math concepts better after using Connect Math to complete my homework assignments	3.50	1.14
The time I spent on Connect Math homework assignments was helpful to me	3.47	1.16
The Connect Math homework assignments matched the classroom instruction	3.73	.92
I understand math topics taught in class better after completing the Connect Math assignments	3.57	.98
In general, I found it easy to enter my answers in the Connect Math program.	2.67	1.32
In general, I found it easy to use the different parts of the Connect Math program	3.27	1.17

Research Question 5

In Research Question 5, I attempted to examine whether math self-efficacy mediated the relationship between class delivery mode and math achievement, hypothesizing that math self-efficacy did mediate the relationship between class delivery mode and math achievement. However, since there was no significant direct effect of class type on math self-efficacy (Hypothesis 1) or math achievement at the .05 level (Hypothesis 3), the assumptions of a mediational analysis were not met and should not be computed.

Further Findings

The last question on the research survey asked the student the highest math course they completed in high school. Since all of these students were in developmental math courses, I wanted to know what level of math they completed in high school to place into these courses. Developmental math courses at the college-level are high school level coursework (beginning and intermediate algebra at the college level is basically algebra one and two in high school). Figure 1 shows the frequency of math courses students stated they completed in high school before they got to college. Table 1 showed that 96.2% of students who participated in the study (with 3.8% failing to enter their age) having graduated high school within the last 4 years. And 84.1% of students surveyed were 18, meaning that they most likely graduated high school within the last school year. The most frequent math course completed in high school for both computer-mediated and traditional lecture-based students was pre-calculus, followed by statistics and algebra 2. The typical sequence of math courses in high school is: Algebra 1, Geometry, Algebra 2, Trigonometry, Pre-Calculus, Calculus 1, and Calculus 2. Computer-mediated and traditional

lecture-based course students had similar frequencies of completed high school math courses. Eight traditional lecture-based students declined to respond to the question, and 1 computer-mediated course student declined to respond. These descriptive statistics suggest that the two samples of students had similar math backgrounds and any differences in their opinions of Connect Math and GPA were unlikely due to differences in math education background. The differences noted in this study seem to be due to the type of college math class in which they enrolled, computer-mediated or traditional lecture classes.

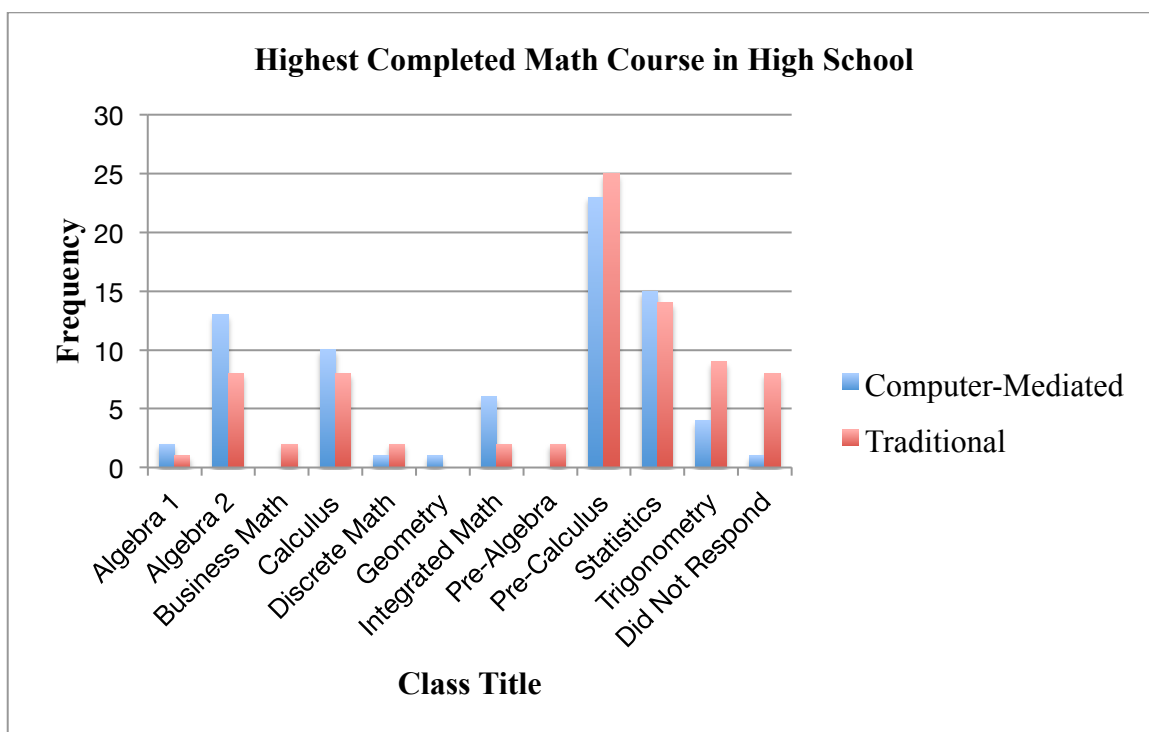


Figure 1. Highest completed math course in high school.

Summary

In my review of the data analyses, I noted several important findings pertaining to math self-efficacy and student opinion (i.e. attitude, perspective, perceived helpfulness) of Connect

Math, and how they each related to math achievement. An ANCOVA was conducted for Research Question 1 to determine if there was a significant difference in math self-efficacy between students enrolled in courses using Connect Math in computer-mediated math courses and traditional lecture-based developmental math courses and found that there was no significant difference in math self-efficacy between students in each course. Although not hypothesized, results did determine that there was a significant relationship between age and math self-efficacy such that as age increased, math self-efficacy increased and conversely, as age decreased, math self-efficacy decreased. This may simply reflect maturation.

An ANCOVA was conducted to examine whether there was a difference in opinion and perceived helpfulness of Connect Math based on delivery method. Results from this test determined that there was a significant difference between class type and student's perceived helpfulness of Connect Math, with computer-mediated students reporting higher perceived helpfulness of Connect Math than traditional lecture-based students. There was, however, no significant difference between student opinions of Connect Math based on delivery mode.

A regression analysis was conducted to determine whether opinion of Connect Math related to math achievement and whether this relationship differed by class mode. No significant interaction was found between class delivery mode and opinions of Connect math on student achievement.

ANCOVA was conducted to test for a statistically significant difference between math achievement in students enrolled in courses using Connect Math in computer-mediated courses and traditional lecture-based courses. Not all students provided their student ID number, and

therefore a total of 113 students were included in this portion of the analysis. Results indicated no significant difference between math achievement and course delivery mode at the .05 level. There was, however, a marginal relationship between class-type on GPA of Connect Math, with computer-mediated students having slightly higher GPAs than traditional lecture-based students.

For the last research question, an attempt was made to examine whether math self-efficacy mediated the relationship between class delivery mode and math achievement, hypothesizing that math self-efficacy mediated the relationship between class delivery mode and math achievement. Since there was no direct effect of class type on math self-efficacy or math achievement, there was no relationship to test.

In Chapter 5, a conclusive summary of the current study is provided, including an analysis and interpretation of the findings, a comparison of the limitations presented in Chapter 1, to the post-study limitations, recommendations for future research, and a discussion that focuses on how the results of this study could have implications for positive social change.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

The purpose of this study was to examine the relationships between math self-efficacy and math achievement in students in computer-mediated and traditional lecture-based developmental courses that used Connect Math. The study explored the differences in student opinion of Connect Math, math achievement and math self-efficacy and the difference between computer-mediated and traditional lecture-based courses. Students from each type of course were enrolled in developmental math courses at CPP during the same fall 2016 term.

In order to complete the goal of graduation from college, students may need to enroll in one or more math courses to satisfy their degree requirements. Students who do not have the proper math background or perform poorly on math placement exams must take developmental math courses before taking college-level courses. Studies such as this one are important because nationally, developmental math courses (compared with developmental reading and writing) have both the highest rates of failure and noncompletion (Adelman, 2004; Fong et al., 2015; Holt et al., 2012). Between 35% and 40% of incoming students are enrolled in developmental courses (Bettinger, Boatman, & Long, 2013; Sparks, & Malkus, 2013). There is a concern among educators about the low success rates among developmental math students and how to best meet the needs of those students (Trenholm, 2006). The following five research questions were designed to examine the relationships between math self-efficacy and math achievement in students in computer-mediated and traditional lecture-based developmental courses that utilized Connect Math:

1. Is there a significant difference between math self-efficacy among students enrolled in courses using Connect Math in computer-mediated math courses and traditional lecture-based developmental math courses?
2. Was there a difference in opinion (i.e. attitude, perspective) of Connect Math based on delivery method (computer-mediated vs. traditional lecture-based)?
3. Was there a significant difference between math achievement among students enrolled in courses using Connect Math in computer-mediated developmental math courses and traditional lecture-based developmental math courses?
4. Did opinion (i.e., attitude, perspective) of Connect Math relate to math achievement among students in developmental math courses and did this relationship differ by class delivery mode?
5. Did math self-efficacy mediate the relationship between class delivery mode and math achievement?

A quasi-experimental quantitative design was used to answer these research questions. The sample was a convenience sample since students self-selected the type of course they enrolled in. The sample size was based upon the number of instructors who volunteered for the study and the number of students in those courses who agreed to participate who were enrolled in developmental math courses in Fall 2016. The sample size for the study was 157 students; 76 students were from computer-mediated courses and 81 were from traditional lecture-based courses. Students were given a survey delivered via SurveyMonkey.com for computer-mediated

students and paper-pencil survey for traditional lecture-based students. Instructors submitted final grades to the researcher at the end of the term.

The study found that there was no significant difference in math self-efficacy between the two classes, but there did emerge a significant positive relationship between age and math self-efficacy. It was concluded that as age increased, math self-efficacy increased and conversely, as age decreased, math self-efficacy decreased. Furthermore, results from the study indicated that there was a relationship between class type and perceived helpfulness of the Connect Math program, with computer-mediated students reporting higher perceived helpfulness of Connect Math than traditional lecture-based students, but there was not a significant difference in student opinion of Connect Math. Results from the open-comment box portion of the survey indicated computer-mediated class generally found Connect Math more helpful and provided more positive comments and fewer negative or mixed comments than students in the traditional lecture-based courses. The study found that instructor significantly predicted student opinion of Connect Math.

Interpretation of the Findings

Although the study found no significant difference between math self-efficacy in students enrolled in courses using Connect Math in computer-mediated math courses and traditional lecture-based developmental math courses, there did emerge a significant positive relationship between age and math self-efficacy. It was concluded that as age increased, math self-efficacy increased and conversely, as age decreased, math self-efficacy decreased. This finding is consistent with studies on age and self-efficacy, which have found that older/nontraditional

students have higher self-efficacy than younger/traditional students (Gupta et al., 2006; Jameson & Fusco, 2014; Spence & Usher, 2007). Since research has found that self-efficacy and self-concept play an important role in math self-efficacy, it is understandable how with age comes more confidence, and this can relate to greater confidence in math (Jameson & Fusco, 2014; Markle, 2017). Since there was no significant relationship between math self-efficacy and class type with the 23 questions from Block 13 of the survey, an ANCOVA run on each individual survey question found that there was a significant relationship between “Picking up a math textbook to begin working on a homework assignment” (Question 4) and class type which shows that computer mediated students have higher math self-efficacy in this instance. When students are highly anxious about math, their competency in the material can be hindered (Ashcraft, 2007).

When examining whether there was a difference between students’ opinion of the Connect Math program and the perceived helpfulness of the program based on delivery mode, results indicated that there was a significant relationship between class type and perceived helpfulness of Connect Math, with computer-mediated students reporting higher perceived helpfulness of Connect Math than traditional lecture-based students, but there was not a significant difference in student opinion of Connect Math. Similarly, studies have found that students who had to use a computer program to complete all practice and tutoring have a more positive evaluation of the computer program, even though the students’ exam performance were worse than the control groups (Jacobson, 2006). Taking into consideration the open-ended portion of the survey, it seemed that students in the computer-mediated class generally found

Connect Math more helpful and provided more positive comments and fewer negative or mixed comments than students in the traditional lecture-based courses. But, there were a significant number of students who complained about the tediousness of inputting equations into the program, similar to other studies on the helpfulness of online math programs (Buzzetto-More & Ukoha, 2009; Holt et al., 2012; Jacobson, 2006).

To examine the relationship between class-type and math achievement, final grades were collected from instructors. Not all students were comfortable providing their student ID number, which significantly impacted the results of the analysis of the study. Seventy-four of the 76 computer-mediated students provided their ID number. Thirty-nine of the 80 traditional lecture-based students provided their ID number. Results indicated a marginal effect of class type on GPA, with computer-mediated students having a slightly higher GPA than traditional lecture-based students. This provided some support for Hypothesis 4. Research on differences in performance of traditional lecture-based students and computer-mediated students have shown mixed results. Some studies found that the computer-based courses had better overall performance (Ashby et al., 2011; Speckler, 2008; Trenholm, 2009). While other studies have found that students in computer-based courses performed worse (Spence & Usher, 2007; Moosavi, 2009). Still others found that programs similar to Connect Math did not significantly contribute to students' pass, withdrawal, and future course success, nor was there a significant difference of performance on homework assignments (Ha, 2014; Kodippili & Senaratne, 2008). However, no specific research was found on the Connect Math program. Since there were no significant findings on which class type resulted in higher GPA, results cannot indicate a

definitive answer on which class type predicts higher math achievement. Therefore, there is no significant difference of math achievement based on class delivery type.

Next, opinion (i.e. attitude, perspective, perceived helpfulness) of Connect Math was examined as a relation to math achievement and whether this relationship differed by class delivery mode. No significant interactions were found between class delivery mode and student opinion but it was found that instructor significantly predicted student opinion of Connect Math. No further analyses were conducted since this relationship was not hypothesized and instructors' identity must be kept confidential. Instructors and their teaching styles can have a significant influence on the success of students (Freeman et al., 2014; Gupta et al., 2006). A separate research study on how much instructors affect students would create a better understanding of this relationship.

Lastly, an attempt was made to examine whether math self-efficacy mediated the relationship between class delivery mode and math achievement; however, since there was no significant direct effect of class type on math self-efficacy (Hypothesis 1) or math achievement (Hypothesis 3) at the .05 level, assumptions of mediational analysis were not met therefore this test was not run.

The theory of self-efficacy served as the theoretical framework of this study. The amount that someone believes they can be successful at a task is determined by their belief that they can complete the task (Bandura, 1986; 1997). Higher self-efficacy relates to higher success in activities. Having negative emotion toward mathematics can yield in low math-self efficacy and can hinder future success in math courses (Ashcraft, 2002; Briley, 2012; Gupta et al., 2006;

Jameson & Fusco, 2014; Markle 2017; Spence & Usher, 2007; Taylor, 2008). Class delivery mode did not show a significant difference in math self-efficacy, but overall, age did show higher results on self-efficacy. This is consistent with research on self-efficacy in that increased age often results in increased self-efficacy (Bandura, 1986; 1997; Gupta et al., 2006; Jameson & Fusco, 2014; Spence & Usher, 2007).

Limitations of the Study

A significant limitation of the study included not having access to all the final grades from all the students participating in the study. This impacted the results of Research Questions 3, 4, and 5. Students may have felt uncomfortable giving their ID numbers, even after being assured that their information would be held confidentially.

Another limitation to the study was that the demographics of the student population in developmental math at this school are not representative of all students all over America. This study also only included two types of developmental math courses and, therefore, did not include all types of developmental math courses available.

There may be additional variables that can affect student GPA beyond what was measured in this study. These could include environmental variables such as family and work responsibilities, or academic variables such as other courses students were enrolled in, how much tutoring they participated in, and how much time students spent doing math course work.

Lastly, instructor influence, and outside of class time was not included in this study. Time spent studying, receiving tutoring help, or meeting with the instructor were not variables in this study, which likely influence math self-efficacy and math achievement (Bremer et al., 2013;

Wang et al., 2017). Also, the instructor type (adjunct vs. professor) was not taken into consideration, as well as how long they have been teaching this particular subject and their effectiveness in teaching.

Recommendations

This study was able to answer four research questions. However, the results and conclusions raise further questions for additional research, including expanding the current research to include more students and more education institutions that utilize Connect Math. This study included a relatively small sample size and involved only seven instructors. With more students involved in the study, a better understanding can be achieved of how this educational tool affects their learning. Additionally, similar studies in varying demographic areas would give more information as well, perhaps even collecting socioeconomic information. Having this information may help with the external validity of the study, creating a better understanding of how these results can be related to an even larger population.

This study can be replicated and altered by assigning individual students random numbers at the beginning of the study (instead of using their student ID numbers) to get their grades at the end of the course. This would give the students more privacy and would also allow for better interpretation of the results.

To get an even better understanding of student opinion of the Connect Math program a qualitative study on the students' opinion and perceived helpfulness of the program may shed more light on how students use and like the program. Students could be interviewed on their initial reactions to the program after first introduced, and then also at the end of a term to see

how their thoughts and opinions of the program change. Another study could track their achievement in the courses following the developmental math courses to see if there is a relationship between class type and successive achievement. Students would need to be tracked for several years, and perhaps until graduation to see their overall performance.

Additionally, approximately 95% of the students who participated in this study were 18 or 19 years old, indicating that they most likely graduated from high school within the last year or two. Further studies could focus on nontraditional students and/or compare nontraditional students versus traditional students in their use of a developmental math educational platform. Since results of this study concluded that older students had higher math self-efficacy, these results may indicate that older student could have higher achievement.

Lastly, a study could include a pre- and posttest to determine which type of course resulted in great understanding of mathematical concepts. This type of study would also aid in the understanding of retention rates of students in developmental math courses.

Implications

U.S. Bureau of Labor Statistics (2017) reported that median income levels for people with only a high school diploma was \$692 a week, while those with bachelor's degrees median earnings were \$1,156 per week. By earning a bachelor's degree, students have the potential of increasing their weekly earnings by approximately 67%. This is a significant figure and one main reason students may want to achieve a bachelor's degree. Colleges and universities have math requirements for incoming students. Developmental math courses were previously notorious in only community colleges, but now can be found at most colleges and universities. It is important

for educators to understand how best to help students prepare and successfully navigate these courses in order to help fulfill their student's dream of attaining a college degree.

While retention rates for developmental math courses are low and the cost of developmental math courses are high, studies are mixed on how helpful these education programs are for students. Some researchers have found positive correlations between developmental education programs and student success rates (Bahr, 2008, 2010; Waycaster, 2011). Other researchers have found that enrolling in developmental math courses actually decreases students' odds of successfully transferring to 4-year institution (Crisp & Delgado, 2014). Studies have suggested that taking developmental math courses early in students' college career are attributed to greater success, while others have found that financial aid and tutoring services were more closely related to student success than developmental coursework (Bremer et al., 2013; Wang et al., 2017). When students have to enroll in developmental math course, their time spent in higher education increases, with less than 60% of students at four-year colleges graduating within six years (Bettinger et al., 2013). Students can then fail to complete their coursework because of the increase in time commitment and financial responsibility (Fong et al., 2015; Holt et al., 2012).

As a way to understand what some universities use to help instruct developmental math courses, this study sought to examine the relationship between students enrolled in two different types of developmental math courses, and whether these students: gave different opinions regarding the Connect Math program used, and whether there were different math achievement outcomes based on class delivery mode. As technology use is creeping into every part of our

society, it is natural that it is found in the classroom, but there remains the question as to if it is helping students achieve better grades in their courses. Students in developmental math courses are learning material that is usually taught in high school. It is important to understand how to help these students be successful with material that most (if not all) of them had been previously exposed to. Schools are faced with pressure to increase student performance and technology is a sought after tool to help increase student performance. Schools also want students to graduate and be successful in their higher education endeavors.

Since a significant positive relationship was found between age and math self-efficacy, this could imply that students would be more successful in developmental math courses if they did not take them in their first year of college. Since self-efficacy increased with age, if students waited longer to complete these courses, there may be a higher success rate.

Although student opinion of Connect Math did not differ by class delivery mode, students in computer-mediated courses felt that Connect Math program was helpful more than traditional lecture-based students. If students in the computer-mediated environment used the program as tutoring option more than traditional lecture-based students, this could be an indicator of their slightly higher GPA.

The findings in this study are significant to public educators because results indicated that greater access to technology (being enrolled in computer-mediated courses), did not significantly predict greater success. This can be comforting to those who may be worried about a significant difference between student achievement in a computer-mediated course and traditional lecture-based course, since this study only found a marginal effect of class type on GPA in their math

course. Students in computer-mediated courses had a slightly higher GPA than traditional lecture-based students. Colleges and universities can be confident in their offerings of various class types to fit the needs of their students.

Conclusion

This study explored the differences in student opinion of Connect Math, math achievement, and math self-efficacy between computer-mediated and traditional lecture-based courses. Students from each type of course were enrolled in developmental math courses at CPP during the same fall 2016 term.

This study investigated the relationships between math self-efficacy and math achievement in students in computer-mediated and traditional lecture-based developmental courses that utilized Connect Math. The study explored differences in math achievement and found that there was a marginal effect of class type on GPA of Connect Math, with computer-mediated students having slightly a higher GPA than traditional lecture-based students. The study also found that there was no difference in math self-efficacy between the two classes, but there did emerge a significant positive relationship between age and math self-efficacy. It was concluded that as age increased, math self-efficacy increased and conversely, as age decreased, math self-efficacy decreased. Additionally, results from the study indicated that there was a relationship between class type and perceived helpfulness of the Connect Math program, with computer-mediated students reporting higher perceived helpfulness of Connect Math than traditional lecture-based students, but there was not a significant difference in student opinion of Connect Math. Results from the open-comment box portion of the survey indicated computer-

mediated class generally found Connect Math more helpful and provided more positive comments and fewer negative or mixed comments than students in the traditional lecture-based courses. While examining opinion of Connect Math in relation to math achievement and if the relation differed by class delivery mode, no significant interactions were found, but it was found that instructor significantly predicted student opinion of Connect Math.

This study contributed to research on Connect Math, since no research studies were found on this particular platform. The results of this study are consistent with similar studies on the MyMathLab program, finding students found it tedious to input answers into the program (Holt et al., 2012). The results of this study are also consistent with research on the MyMathLab program finding that students earned no significant difference in score, final grade, or success rate between course delivery-mode (Ha 2014; Pope 2013). This study was in contrast to Ashby et al. (2011) and Trenholm (2009) who found that online and computer-mediated students performed better in developmental math courses. The combined results of this study and others involving math achievement and educational technology in computer-mediated and traditional lecture-based courses indicate that further research is needed to explore other contextual factors that may affect performance, self-efficacy, and opinion of certain technology platforms.

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Appendix A: Questionnaire

Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students

Information about Being in a Research Study Walden University

Examining the Relationship Between Math Achievement and Math Self-Efficacy in Developmental Math Students

Description of the Study and Your Part in It

Ellen Prescott is inviting you to take part in a research study about the use of the Connect Math program. Ellen Prescott is a doctoral student in the Education Department at Walden University, running this study with the help of Dr. Dennis Beck and Dr. Bettina Casad. The purpose of this research is to explore the relationship between developmental math student's achievement and self-efficacy. This study involves students in developmental math courses who are 18 and over.

Your part in the study will be to complete a short online survey about your use of the Connect Math program associated with your math course and your feelings toward mathematics in conjunction with your final grade in your math course. Your student ID number will be requested so that it can be associated with your final course grade.

It should take you less than 20 minutes to complete the survey. The survey can be completed online at: https://www.surveymonkey.com/r/prescott_dissertation

In order to ensure accuracy of the results only fully completed surveys can be used. If there are questions you do not want to answer, you may discontinue participating at any time.

Risks and Discomforts

There will be minimal risks associated with this study, no more than expected in daily life.

Possible Benefits

The anticipated benefits of your participation in the study will be the contribution of your responses to research concerning math self-efficacy and the use of the Connect Math program. An analysis of the study will be shared with instructors of developmental math and the director of the developmental math program. In addition, we will seek publication of the study's findings in journals focused on developmental education. The results of the study may be used to

inform the practice of developmental educators and therefore guide instructional decisions concerning the use of computer-based programs.

Incentives

There are no incentives to participating in this study.

Protection of Privacy and Confidentiality

I will do everything I can to protect your confidentiality. Your name will not be associated with the research findings. All of your responses will remain confidential. Your name and instructor information is gathered only to associate your responses with final course grades. Any printed materials associated with the research will be stored in a locked file cabinet. Digital records of the study will be stored on a password-protected computer. Only the researcher will have access to the survey response data collected through the study.

Choosing to Be in the Study

Participation in this study is voluntary. You may choose not to take part and you may choose to stop taking part at any time without penalty. You will not be punished in any way if you decide not to be in the study or discontinue taking part in the study. If you decide not to take part or stop taking part in this study, it will not affect your grade in any way.

Contact Information

If you have any questions or concerns about this study or if any problems arise, please contact the researcher at

Ellen Prescott
Walden University
XXX-XXX-XXXX
ellen.prescott@waldenu.edu

or the advisor at

Dr. Dennis Beck Department of Education Walden University
XXX-XXX-XXXX
dennis.beck@waldenu.edu

If you have any questions or concerns about your rights in this research study, please contact the IRB department at

Institutional Review Board (IRB) Walden University
100 S. Washington Ave. #900
Minneapolis, MN 55401
612-312-1210/IRB@waldenu.edu

Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students

Consent

By beginning the survey, you acknowledge that you are at least 18 years old, have read this consent form, have understood the above information, and agree to voluntarily participate in this research.

If you would like a copy of this form for your reference, you may print this out.

- * 1. I have read the Informed Consent document for the Connect Math study, and I understand the purpose and nature of the study as it is described.

- I am 18 years old or older and am willing to participate in the Connect Math study. I understand my rights as a participant in the study. (If you select this box, please continue to the next page to complete the survey)
- I am not willing to participate in the Connect Math study or am under the age of 18. I understand that my decision not to participate will not affect my standing with my instructor or the college.

Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students

2. Before taking this course I was comfortable using a computer.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. In general, I found the Connect Math program to be user-friendly.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. In general, I liked doing my homework on Connect Math instead of doing paper and pencil homework.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

5. I understand math concepts better after using Connect Math to complete my homework assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. The time I spent on Connect Math homework assignments was helpful to me.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. The Connect Math homework assignments matched the classroom instruction.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. I understand the math topics taught in class better after completing the Connect Math assignments.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9. In general, I found it easy to enter my answers in the Connect Math program.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. In general, I found it easy to use the different parts of the Connect Math program.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. Please add any comments regarding your opinion of Connect Math.

Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students

12. Please rate each aspect of the Connect Math program based on how helpful it has been to you.

	I did not use this	Not very helpful	Somewhat unhelpful	Somewhat helpful	Very helpful
Immediate feedback on my answer to a problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Option to see the problem worked out step by step with Help Me Solve This	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	I did not use this	Not very helpful	Somewhat unhelpful	Somewhat helpful	Very helpful
Option to see more problems like this one with View an Example	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to access the textbook online	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to review my homework assignment after I have completed it	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to see assigned homework and due dates	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to see my grades on each assignment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to start an assignment, save it, and come back to finish it later	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to rework questions as many times as I need to	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Option to view video instruction for each section of the textbook	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Access to a Tutor Center	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Option to complete sample quizzes, chapter reviews, and chapter tests	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Option to view a video example for each problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to Ask My Instructor about a specific assigned homework problem	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ability to see course announcements from my instructor reminding me of important information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. Please indicate the level of your anxiety in the following situations. (One choice per line.)

	Not at all	A little	A fair amount	Much	Very much
Studying for a math test.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Taking the math section of the college entrance exam.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Taking an exam (quiz) in a math course.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Picking up a math textbook to begin working on a homework assignment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being given homework assignments of many difficult problems that are due the next class meeting.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thinking about an upcoming math test 1 week before.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thinking about an upcoming math test 1 day before.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Thinking about an upcoming math test 1 hour before.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Realizing you have to take a certain number of math classes to fulfill requirements.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Picking up a math textbook to begin a difficult reading assignment.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Opening a math or statistics book and seeing a page full of problems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Getting ready to study for a math test.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being given a "pop" quiz in a math class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Reading a cash register receipt after your purchase.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Not at all	A little	A fair amount	Much	Very much
Being given a set of numerical problems involving addition to solve on paper.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being given a set of subtraction problems to solve.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being given a set of multiplication problems to solve.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Being given a set of division problems to solve.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Buying a math textbook.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Watching a teacher work on an algebraic equation on the blackboard.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Signing up for a math course.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Listening to another student explain a math formula.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Walking into a math class.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students

14. What is the last name of your instructor?

15. What is your student ID number?

16. What is your gender?

Female

Male

17. What is your age?

18. Please describe your race/ethnicity.

19. What is the highest level of math you took in high school?

Thank you for taking the time to complete the survey!

Appendix B: Initial Email

My name is Ellen Prescott and I am a doctoral student at Walden University. I am conducting my dissertation study on Examining the Relationship Between Math Achievement and Math Self-Efficacy. I am interested in California State Polytechnic University, Pomona because I have an online component to my research questions. If you could please point me in the direction on who I can be in contact with, I would greatly appreciate it. I look forward to your communication.

Thank you,

Ellen Prescott

Appendix C: Second Email

Thank you for getting back to me. As far as my study goes, I am examining how Connect Math plays a role in self-efficacy changes. My main question for you is: do the computer-mediated and lecture-based developmental math courses at CPP use Connect Math? My research questions are:

1. Is there a significant difference between math self-efficacy in students enrolled in courses using Connect Math in online developmental math courses and traditional lecture-based developmental math courses?
- 2a. Is there a difference in opinion of Connect Math based on delivery method (online vs. traditional lecture-based)?
- 2b. Does opinion of Connect Math relate to math achievement in students in developmental math courses and does this relationship differ by class delivery mode?
3. Is there a significant difference between math achievement in students enrolled in courses using Connect Math in online developmental math courses and traditional lecture-based developmental math courses?
4. Does math self-efficacy mediate the relationship between class delivery mode and math achievement?

Data collection would be in the form of an online survey at the end of the term/semester using the following link: https://www.surveymonkey.com/r/prescott_dissertation

Ellen Prescott

Appendix D: Introduction to Study Paragraph

Ellen Prescott is inviting you to take part in a research study about the use of the Connect Math program. Ellen Prescott is a doctoral student in the Education Department at Walden University, running this study with the help of Dr. Dennis Beck and Dr. Bettina Casad. The purpose of this research is to explore the relationship between developmental math student's achievement and self-efficacy. I am requesting that you allow me access to your final course grade (provided by your instructor). Your part in the study will be to complete a short online survey about your use of the Connect Math program associated with your math course and your feelings toward mathematics. In order to ensure accuracy of the results only fully completed surveys can be used. If there are questions you do not want to answer, you may discontinue participating at any time.

https://www.surveymonkey.com/r/prescott_dissertation

Appendix E: Survey Permission #1

Math 131 MyMathLab Survey (Diana Holt)

Donna Holt
Mon 11/16/2015, 7:01 PM Ellen Prescott
Papers
Ms. Prescott,

Congratulations on reaching this stage of your doctoral studies! I can certainly grant you permission to use the survey instrument I developed for your dissertation study. And I would be very interested to receive the results of your study once it is completed. Please let me know if I can be of any further help in your current work.

With best wishes for a successful study,

Donna Holt

On Mon, Nov 16, 2015 at 3:07 PM, Ellen Prescott wrote:

Donna Holt:

I am a doctoral student from Walden University writing my dissertation titled Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students, under the direction of my dissertation committee chaired by Dr. Dennis Beck who can be reached at [XXX.XXX.XXX/dennisebeck@waldenu.edu](mailto:XXX.XXX.XXX@dennisebeck@waldenu.edu). The Walden University IRB can be contacted at irb@waldenu.edu.

I would like your permission to use your Student Perceptions of Connect Math survey/questionnaire instrument in my research study. I would like to use and print your survey under the following conditions:

- I will use the surveys only for my research study and will not sell or use it with any compensated or curriculum development activities.
- I will include the copyright statement on all copies of the instrument.
- I will send a copy of my completed research study to your attention upon completion of the study.

If these are acceptable terms and conditions, please indicate so by replying to me through e-mail: ellen.prescott@waldenu.edu

Sincerely,

Ellen L. Prescott
Doctoral Candidate

Appendix F: Survey Permission #2

Abbreviated Version of the Mathematics Anxiety Rating Scale (A-MARS) (Richardson and Suinn)

From: Alexander, Livingston
To: Ellen Prescott
Oct 4, 2016 at 9:09 AM

Dear Ms. Prescott,

Sorry about the delay in responding. I've been away from campus. I do grant permission for you to use the Abbreviated MARS for your research.

Best,

Livingston Alexander

President

University of Pittsburgh at Bradford and Titusville Campuses

From: Ellen Prescott
Sent: Tuesday, October 4, 2016 11:04 AM
To: Alexander, Livingston
Subject: Doctoral Student

Dr. Alexander

I am a doctoral student from Walden University writing my dissertation titled Examining the Relationship Between Math Achievement and Self-Efficacy in Developmental Math Students, under the direction of my dissertation committee chaired by Dr. Dennis Beck who can be reached at XXX.XXX.XXX/dennis.beck@waldenu.edu.

In the October 1989 issue of "Measurement and Evaluation in Counseling and Development" you presented a 25-item scale called the "Abbreviated Mathematics Anxiety Rating Scale." I am

requesting your permission to use your scale as the instrument to measure mathematics anxiety during my dissertation study.

I would like to use and print your survey under the following conditions:

- I will use the surveys only for my research study and will not sell or use it with any compensated or curriculum development activities.
- I will include the copyright statement on all copies of the instrument.
- I will send a copy of my completed research study to your attention upon completion of the study (if requested).

If these are acceptable terms and conditions, please indicate so by replying to me through e-mail: ellen.prescott@waldenu.edu.

Sincerely,

Ellen L. Prescott

Doctoral Candidate