DELIVERY OF REMEDIAL COMMUNITY COLLEGE MATHEMATICS INSTRUCTION IN AN EMPORIUM LEARNING ENVIRONMENT: PREDICTING ACADEMIC SUCCESS, PERSISTENCE, RETENTION, AND COMPLETION

by

Mark Douglas Little

A dissertation submitted to the faculty of
The University of North Carolina at Charlotte
in partial fulfillment of the requirements
for the degree of Doctor of Education in
Educational Leadership

Charlotte

2016

Approved by:

____
Dr. Mark D'Amico

____
Dr. Lynn Ahlgrim-Delzell

____
Dr. Mickey Dunaway

____
Dr. Susan Harden

ABSTRACT

MARK DOUGLAS LITTLE. Delivery of remedial community college mathematics instruction in an emporium learning environment: Predicting academic success, persistence, retention, and completion. (Under the direction of DR. MARK D'AMICO)

The purpose of this study was to find predictors of academic success, persistence, retention, and completion for students enrolled in community college developmental education mathematics courses utilizing an accelerated emporium model learning environment**.** Instructional practices have been shown to have a powerful impact on the desire and motivation of students to succeed in mathematics courses. The literature suggests that the body of research looking at innovative acceleration and completion options for developmental mathematic courses may be seen as broad and inconclusive, with numerous methodologies and research designs having been tried with varying levels of success. Data for this study included age, ethnicity, gender, financial aid status, enrolled course and grades of students who completed MAT 060, MAT 070, and MAT 080 during the spring 2011 semester. The length of employment and employment status for instructors was also obtained. The sample of convenience included 376 students who either enrolled in traditional- or emporium-format sections of the courses listed above. The researcher utilized logistic regression to answer all of the research questions. Key findings of the study indicated that predictors such as course format, financial aid status, and age accounted for 10 – 21% of the variance in specific criterion variables. These findings point to a realization that the process of getting underprepared community college mathematics students to perform at the college level may take an all-of-the-above strategy, with emporium model learning environments as just one item in a large portfolio of active interventions. In addition to a detailed presentation of the results, this study also discusses recommendations for policy and practice, as well as suggested avenues for future research.

DEDICATION

This dissertation is dedicated to community college developmental mathematics faculty who work every day to ensure their students have an opportunity to achieve the American dream.

ACKNOWLEDGEMENTS

I would like to acknowledge and thank my family, friends, colleagues, faculty in the Department of Educational Leadership, and the members of my Dissertation Committee for their unwavering support and belief in me during this long journey. I especially wish to recognize and express my gratitude to Dr. Mark D'Amico and Dr. Lynn Ahlgrim-Delzell. They displayed infinite patience and guidance through hours of conversation and hundreds of emails. The value they saw in my work instilled in me the drive to finish.

> Nothing in the world can take the place of persistence. Talent will not; nothing is more common than unsuccessful men with talent. Genius will not; unrewarded genius is almost a proverb. Education will not; the world is full of educated derelicts. Persistence and determination alone are omnipotent. The slogan 'press on' has solved and always will solve the problems of the human race.
>
> - Calvin Coolidge

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Overview

Developmental education is an essential part of the community college mission (Quirk, 2005). Developmental education programs within community colleges are designed to identify students who are academically underprepared and quickly instill the knowledge and skills necessary for them to function at the college level (Boylan, 2002). It is estimated that developmental education programs prevent over two million students each year from dropping out of a postsecondary education program (McCabe & Day, 1998). Regardless of this statistic, developmental education programs are being challenged today on a number of fronts.

The goal of this study was to investigate strategies that hold the most promise for moving students through developmental education mathematics courses. The research questions posed in this study covered the fundamental areas of academic success, persistence, retention, and completion for students enrolled in developmental mathematics courses. The intent is that this study and the results stemming from it will prompt additional discussion and research focusing on successful strategies for the implementation of mathematics remediation in postsecondary environments.

The genesis for this study is research and statistics from the past 20 years which reveal upwards of 60 percent of students who enter a community college must take one or more developmental education courses; of those, less than half successfully complete a program of study (Smith & Others, 1996; U.S. Department of Education, 2003; Zavarella & Ignash, 2009). More recent data indicate that the percentage of community college students placing into developmental math courses ranges from 42%-95% (Bailey, Jeong, & Cho, 2010; National Center for Education Statistics, 2012).

The number and sequence of developmental education courses a student may be required to take are driven by their placement test scores or equivalent multiple measures. This leaves students taking as many as four or more semesters of courses which do not count toward their program of study, carry no curriculum credit, and do not transfer to a four-year institution (Sherer & Grunow, 2010). This unexpected academic detour decreases the likelihood that students, who may juggle a job, family, and academic responsibilities, will meet their educational goals (Attewell, Lavin, & Domina, 2006).

Developmental mathematics courses have emerged as a particular challenge for students (Jones, 2012). 2012 statistics from The American Association of Community Colleges indicate that two out of every three students placed in a developmental mathematics course sequence do not complete it successfully (American Association of Community Colleges, 2012a). The non-completion rate is even higher for students placed at the lowest levels of a developmental mathematics course sequence; 83% of students who are placed at least three levels below a college-level mathematics course never complete the sequence (Boylan, 2002; Jones, 2012). This failure to complete a long, prescribed developmental sequence may have more to do with the student's option of exiting the sequence after each class, rather than their academic abilities. Boylan (2002) indicated that more students exit a developmental mathematics course sequence from not maintaining continuous registration than from those who fail or withdraw.

Beyond structural obstacles, opportunities exist to investigate how instructional technique may predict developmental mathematics retention, persistence, completion, and success rates. The history of developmental mathematics courses is characterized by a focus on traditional lecture and rote learning activities. This approach leaves room for new classroom pedagogies that utilize student engagement and collaboration (Cannon, 2005).

The pilot program analyzed as part of this study took place during spring 2011 at an urban community college located in North Carolina, as the institution addressed the developmental education issues above by researching how different course formats may predict academic success, persistence, retention, and completion of their developmental education students enrolled in three developmental mathematics courses (National Center for Academic Transformation, 2012). The content for each course was defined by the curriculum standards issued by the North Carolina Community College System. The college experiences an average enrollment in all three of these developmental mathematics courses of approximately 3,700 students per semester. The average pass rate for these courses is 48% (National Center for Academic Transformation, 2012).

Instructors in these courses utilized a standard, department-wide syllabus and curriculum. The required textbooks for these courses incorporated MyMathLab, an interactive mathematics instruction software package produced by Pearson Education. The college has recently dealt with rapid growth in enrollments for their developmental mathematics courses, with the numbers increasing by 33% in 2010 alone (National Center for Academic Transformation, 2012).

The impetus for this study stemmed from a number of chronic issues plaguing the college's developmental mathematics program. These issues included the inability of students to complete more than one course per 16-week semester, the low numbers of students who completed a course on first attempt, student frustration at the inability to move through the courses as they demonstrated concept mastery, and the large number of students who did not retain their mastery of concepts when moving from one course to the next. The college's focus on this initiative took place at the same time that the North Carolina Community College System launched the statewide Developmental Education Initiative (DEI), which sought to increase the number of students who successfully complete developmental education courses and enroll in college-level courses (Liston, 2014).

As part of this redesign of three existing developmental math classes–Essential Mathematics, Introductory Algebra, and Intermediate Algebra–the college modified the developmental mathematics curriculum using an emporium model course delivery format. Developed by the National Center for Academic Transformation (NCAT), the emporium model used by the college allowed students to access interactive software modules utilizing computer-assisted instruction. These modules provided the equivalent of a course "lecture", and delivered all formative and summative course assessments. Instructors were present to work one-on-one with students to deliver focused, individualized course guidance. When a student demonstrated mastery via a post-test, they would move on to the next module. With NCAT's assistance, 13 modules were created from the three existing courses (National Center for Academic Transformation, 2012).

Changes in technology are causing more students to expect technology-intensive modalities of instruction. Computer-assisted instruction is being adopted as a solution. However, with the promise of computer-assisted instruction comes an equal number of challenges. Within the overall portfolio of applicable research studies, few of them focus specifically on the impact of computer-assisted instruction on the academic success of developmental mathematics students (Perez, 1997). A few studies reveal some promise related to the use of technology within remedial mathematics, but it appears that the pace of innovation and implementation has moved ahead of systematic research measures for assessment and evaluation (Epper & Baker, 2009).

Numerous colleges and related organizations have instituted studies in recent years looking at the efficacy of technology within the developmental mathematics environment, but the results so far have not pointed to a single technology as consistently and repeatedly effective (Golfin et al., 2005).

Over the past 30 years, great strides have been made in the quality of instructional technologies. These systems have now reached a level of maturity and sophistication such that they hold promise for creating an individualized, and therefore more effective, learning experience for each student (Kinney & Robertson, 2003). But this promise cannot be realized until educational organizations have a practical model for how these systems may be implemented as part of a strategy to help students quickly build college-level competencies.

Need and Purpose

There is a need to examine how courses that are redesigned based on the emporium model will affect student achievement in mathematics compared to traditional mathematics lecture courses (Ma & Xu, 2004). This study attempted to determine if students in the treatment group, who were exposed to the accelerate emporium course format, achieved statistically significant improvements in academic success, retention, persistence, and completion, versus those students in the comparison group.

As part of its 21st-Century Initiative, the American Association of Community Colleges has established a goal of graduating an additional 5 million community college students with an earned degree, diploma, or industry certification by 2020 (American Association of Community Colleges, 2012a). Such a goal will require substantial improvement in the pace of students completing remedial course sequences on the first attempt.

A college education is fast becoming a requirement for anyone wishing to enter the U.S. middle class. From 1970 to 2007, the percentage of high school graduates considered to be in the American middle class fell from 60 percent to 45 percent. During the same timeframe, individuals with college degrees have either remained in the middle class, or moved upward into higher income brackets (Carnevale, Smith, & Strohl, 2010).

Individuals with college degrees or higher not only had the lowest unemployment rates during and after the recent recession, but also found new employment at the highest rate of any employee segment. These data indicate that those without some level of postsecondary education or training are at the highest risk of being left unemployed or underemployed as the economy continues to recover (Carnevale & Smith, 2010). According to a study published by Carnevale, Smith, & Strohl (2010), almost two thirds of all jobs in the United States will require some type of college-level training by 2018. This same study also revealed that, since 1980, the demand in the United States for college graduates has outstripped the supply produced annually by four-year colleges and universities. This gap has created an opportunity for community colleges. If this gap can be closed over the next 15 years by the addition of 20 million individuals to the U.S. workforce who possess college-level skills, stagnant income levels among the U.S. middle class, and the resulting income inequalities, are projected to decline significantly as a result (American Association of Community Colleges, 2012).

Community colleges are currently grappling with a combination of the following: low student success rates; a disconnect between the skill needs of employers and the content of college training programs; and barriers that inhibit a seamless pathway students between high school, community colleges, and four-year institutions. These issues are beginning to impact the long-standing role of community colleges as gateways to higher education for the American middle class (American Association of Community Colleges, 2012).

The enrollment-centric funding model originally put in place to support community colleges provided funding based on a calculation of full-time equivalent students who remained enrolled after a specific milestone date at the beginning of a semester (Lumina Foundation, 2013). This model presents challenges to institutions, who find themselves incentivized to enroll and retain students through the beginning of the semester, but are not rewarded for supporting students and ensuring that they are successfully completing a program of study. This hinders progress for historically underserved populations, such as low income students and other at-risk populations (American Association of Community Colleges, 2012).

Institutions and standards bodies are beginning to propose an alternative to this traditional funding and management model. This new model is focused not on enrollment numbers, but on student success; not on fragmented course selection, but on defined pathways that connect knowledge and skills to the needs of the job market; not on fragmented student support initiatives, but on focused strategies that promote high rates of academic success persistence, retention, and completion (American Association of Community Colleges, 2014).

And at the state level, legislatures are beginning to drive the move toward funding models that better align with their state goals and priorities by reducing emphasis on process indicators and increasing the emphasis on outputs as key accountability indicators (D'Amico, Friedel, Katsinas, & Thornton, 2014; Lumina Foundation, 2013).

One such legislature is in North Carolina. In 1998, the state's General Assembly passed statutes directing the State Board of Community Colleges to: 1) begin the process of systematically reviewing all performance measures and accountability standards; and 2) begin developing the framework for a performance – based funding model (Ralls, Morrissey, Schneider, Corbell, Ingoglia, & Mbella, 2013). With the goal of developing a stronger system for public accountability, the community college system began the work of developing what would eventually become a set of 12 performance measures for accountability. The measures, announced in 1999, were later deemed by the community college system as the core indicators of student success throughout the 58-college network.

These 12 measures, termed Critical Success Factors, continued to be published annually by the community college system throughout the 2000s. The General Assembly directed revisions to these measures during their 2011 sessions. These revisions were aimed at updating methods of measurement, and for the first time included graduation rates and course completion rates (Ralls et al., 2013). The revisions also brought with them a link to the allocation of performance funding. The updated measures were approved in 2012. As a means to track progress, baselines were established in the following areas: Academic progression in the first year of enrollment, passing rates for licensure and certification exams, subsequent college-level English course performance for developmental education students, subsequent college-level math course performance for developmental education students, program of study completion, academic performance for students in college transfer pathways, academic progress of basic skills students, and passing rates for students enrolled in GED diploma programs (Ralls et al., 2013).

These broadened measures now provide a clear picture of how each of the 58 colleges in the North Carolina community college system is performing when compared to their peer institutions. And their performance is now tied to a portion of their funding for the coming year (Ralls et al., 2013). Evidence-based accountability and performance standards such as these represent the broader, national push by policy makers to create a different culture of postsecondary accountability focused on the areas of student retention, persistence, and success (American Association of Community Colleges, 2013).

The preceding paragraphs covering the performance funding issue reveal the prominent role that remedial courses currently play in the calculation of individual institutions' accountability metrics. Feedback from regulatory and funding bodies indicates that the portion of budgets allocated according to performance measures will only increase going forward. This will place even more pressure on administrators to improve remedial courses passing rates.

The challenge of higher education attainment and its impact on the middle class is best shown in the challenges experienced by employers when seeking qualified job applicants. A 2013 report by the Lumina Foundation noted that 33% of employers surveyed indicated an applicant’s lack of technical skills and competencies as their main challenge in filling vacant jobs **(**Lumina Foundation, 2013**).** The technical skills gap is most acute in manufacturing, where a 2012 Lumina report indicated that two-thirds of manufacturers surveyed reported a moderate to severe shortage of qualified applicants (Lumina Foundation, 2013).

Technology innovation is a primary driver for 21^{st}-century economies. The pace of these innovations requires employees who possess the abilities to both think critically and to perform complex tasks. The demand for these types of workers then increases across the economy as technology innovation is adopted (Carnevale & Smith, 2010). Companies are relying on higher education institutions to graduate employees who have gained these skills by earning degrees, diplomas, and certificates, but the pace of this work is not keeping up with demand. It is estimates that by 2018, the number of positions requiring Associate’s degrees will exceed the applicant pool by three million. Community colleges will have to increase the pace at which they confer degrees by 10 percent per year in order to erase this shortfall (Carnevale, Smith, & Strohl, 2010). Given the number of community college students who are placed into remedial courses, college administrators and employers alike are looking for ways to accelerate the pace of remedial course completion, as a method of increasing the overall numbers of individuals who are completing college degrees, and are therefore qualified to fill positions in the evolving knowledge economy.

The purpose of this research study was to look at the delivery of developmental mathematics instruction in an accelerated emporium model learning environment, and how it may predict academic success, persistence, retention, and completion for students enrolled in developmental education math courses. Access to and use of computer-assisted instructional programs was analyzed.

Statement of the Problem

The academic success, persistence, retention, and completion issues surrounding developmental mathematics education in the community college represent some of a matrix of academic challenges confronting leaders at community college throughout the country. These institutions are also facing college transfer barriers, low program completion rates, and disparities in academic achievement across various student groups (American Association of Community Colleges, 2012).

Since the advent of community colleges and the promise of an open admissions pathway to a postsecondary degree, educators and institutions have taken on the challenge to demonstrate that everyone is capable of performing academically at the college level. The flipside of this challenge is to then create remedial programs that will meet students where they are academically, and thus ensure that all community college aspirants are equipped with the skills necessary to achieve their academic goals. Mathematics remediation, in particular, has served as a consistent barrier to this promise. The rates have varied over the decades, but on average, over 60% of enrolled community college students are placed into one or more developmental mathematics courses (Bailey, Jeong, & Cho, 2010; Clery, Solorzano, & Achieving the Dream, 2006; Jones, 2012). Once in these courses, students are facing a strong headwind, with as many as 80% not completing their prescribed developmental mathematics course sequence within three years (Bailey, Jeong, & Cho, 2010).

Research has indicated that instructional practices can have a profound impact on the motivation and desire of students to succeed in mathematics, and that this desire can be more powerful than any innate mathematics ability (Middleton & Spanias, 1999). However, such finding are tempered by the reality that the more time students spend in a developmental education mathematics course sequence, the more likely they are to drop out of college (Bettinger & Long, 2009).

Instructional options such as the emporium model that both accelerate developmental education courses and use classroom techniques that allow for more one-on-one instruction are an opportunity for solving these challenges. Community colleges are increasingly moving to accelerated developmental mathematics course delivery formats that offer self-paced instruction and embedded one-on-one instruction and support, with the goal of more quickly moving students into college-level courses (Seymour & Academic Senate for California Community Colleges, 2009).

Some students who successfully complete these accelerated courses are demonstrating their ability to succeed, persist, be retained, and complete at the same or better rates than students enrolled in traditional developmental mathematics courses (Cho, Kopko, Jenkins, & Jaggars, 2012). But the overall body of research looking at these innovative acceleration and completion options for developmental mathematic courses may be seen as broad and inconclusive, with numerous methodologies and research designs having been tried with varying levels of success (Berryman & Short, 2010; Golfin et al., 2005; Hodara, 2011; National Center for Academic Transformation, 2005; Quint et al., 2011; Rutschow, 2011; Spradlin & Ackerman, 2010; Twigg, 2011; Van Campen, Sowers, & Strother, 2013).

Instructional administrators stand at this crossroad, observing these numerous studies and the wide-ranging pathways they offer for improving developmental education programs, and they need answers. This study helped to clarify these pathway options by tracking developmental students through a remedial mathematics course sequence and into college-level work, thus delivering a study that utilized a rigorous research model to provide another piece of evidence as to what works and does not work with remedial mathematics students in the community college setting.

Research Questions

The research questions for this study are as follows:

- **Q1:** How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict developmental mathematics course completion?
- **Q2:** How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict first-to-second-semester developmental mathematics course persistence?
- **Q3:** How well does developmental mathematics course format predict retention?
- **Q4:** How well does developmental mathematics course format predict gateway curriculum mathematics course completion?

- **Q5:** How well does developmental mathematics course format predict the success of students as measured by transfer, completion of a curriculum terminal degree, diploma or certificate within 150% of normal time, or continued enrollment?

Operational definitions for the variables referenced in each research question are provided in the Definitions section below.

Research Design

This non-experimental, *ex post facto* quantitative study investigated how well course format predicted academic success, persistence, retention, and completion of developmental education mathematics courses for two groups of students enrolled in either a traditional or accelerated emporium learning environment. The research questions were examined using data collected from student records.

The study took place at one institution, a community college in North Carolina. A non-experimental design was used in this study, since the participants were not randomly assigned to treatment and control groups, but instead were selected based on the way they self-enrolled in classes. Thus, the sample in this study was a sample of convenience. A non-experimental design is primarily identified by a lack of randomization and fidelity assurance procedures (Huck, 2012). Nonetheless, this is a necessary method because of human considerations. Both ethical and logistical issues create barriers to the random assignment of students, who have paid for their education, into intervention and comparison groups using different instructional methods. See Table 1 for a summary of the research questions and research design methods.

Table 1: Summary of Research Questions and Methods

Research Question	Predictor Variable (Independent Variable)	Criterion Variable (Dependent Variable)	Statistical Test
Q1: How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict developmental math course completion?	Student demographics - Age; Student demographics–Gender; Student demographics–Ethnicity; Student demographics–Financial aid status; Enrolled course; Course format; Course instructor–Employment status; Course instructor–Length of employment	Developmental mathematics course - Completion	Logistic regression
Q2: How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict first-to-second-semester developmental math course persistence?	Student demographics - Age; Student demographics–Gender; Student demographics–Ethnicity; Student demographics–Financial aid status; Enrolled course; Course format; Course instructor – Employment status; Course instructor–Length of employment	Persistence	Logistic regression
Q3: How well does developmental	Enrolled course; Course format	Retention	Logistic regression

(continued)

mathematics course format predict retention?			
Q4: How well does developmental mathematics course format predict gateway curriculum mathematics course completion?	Enrolled course; Course format	Gateway curriculum mathematics course - Completion	Logistic regression
Q5: How well does developmental mathematics course format predict the success of students as measured by transfer, completion of a curriculum terminal degree, diploma, or certificate within 150% of normal time, or continued enrollment?	Enrolled course; Course format	Student success-College transfer; Student success–Completion; Student success–Continued enrollment	Logistic regression

A quantitative approach was used to analyze the research questions in this study. Data analysis utilized both descriptive and inferential statistical procedures. Descriptive statistics were used to compare differences among students on the individual characteristics of age, gender, ethnicity, and financial aid eligibility. All data analysis was completed using the Statistical Package for the Social Sciences (SPSS), version 23.0 (UNC Charlotte, n.d.).

For the inferential procedures, logistic regression was used to first determine if student demographics, course format, and course instructor predicted developmental mathematics course persistence and completion. Next, additional logistic regression analysis procedures were conducted to determine whether course format predicted retention, credit-bearing math course completion, transfer within 150% of normal time, completion of a curriculum terminal degree, diploma, or certificate within 150% of normal time, or continued enrollment.

Logistic regression was used in this study because of its ability to model dichotomous, discreet or categorical outcome variables based upon a combination of predictors (Huck, 2012). In logistic regression, there are no assumptions about the distribution of the predictor variables (Huck, 2012). Statistical analysis in educational research must accommodate multiple research factors, which makes consideration of the relationships effects among all factors a key metric when selecting an appropriate statistical procedure (Huck, 2012). Because of these and other considerations, logistic regression analysis has often been selected by educational researchers over the decades as a preferred statistical method (Howell, 2011). Data analyzed with logistic regression do not need to be normally distributed, nor is there a requirement of equal variance within each group being studied (Garson, 2012; Huck, 2012).

Significance

Many studies that investigate instruction utilizing computer technology are lacking important critical analysis components, such as a comparison of student success rates between classrooms that use computers and those that do not, an analysis of cost vs. benefits, and a focus on the self-paced nature of computer-assisted instruction and its effect on learning (Hattie, 2013). The review of literature in this study clearly showed that evaluations of computer-assisted instructional programs are a necessary part of the educational process in order to propose changes for improvement to the program.

Mathematics seems to be very difficult and discouraging for students. Traditional teaching methods seem to work very well with students who have strong mathematical abilities but does not work well with developmental students who have weak mathematical abilities (Spradlin, 2010). Many high school students have completed the core mathematics requirements but fail to score into college-level courses when taking placement tests. If emporium model instruction increases the pass rates of developmental mathematics students, then the benefits of requiring this technology in the classroom will be realized.

The challenges of remediation and student retention are two of the greatest barriers to improved student success and completion rates in higher education (Boylan & Bonham, 2011; Brothen & Wamback, 2004; Roueche & Roueche, 1993; Schrag, 1999). Among the current statistics available is a finding that more than 60% of students who apply to community colleges are identified as needing remediation based on their placement test scores (Rutschow & Schneider, 2011). Further, a study of first-time community college students revealed almost 50% had not completed any program of study six years after taking their first classes (American Association of Community Colleges, 2012; Attewell, Lavin, Domina, & Levey, 2006).

Boylan (1999) estimated that some 90% of community colleges, and 70% of universities, offer some type of remedial coursework focusing on mathematics, reading and English, with these programs serving some 2.5 million students per year.

Integration of technologies into the remedial classroom may be one path forward. When students are involved with computer-assisted instruction in a self-paced environment, they may appear to be learning independent of the teacher. However, this creates an opportunity for the instructor to spend less time lecturing during classroom instruction, and spend more time attending to the daily management tasks associated with monitoring and providing feedback on student progress. In this way, the instructor is able to assist individual students and small groups of students with their specific learning needs (National Council of Teachers of Mathematics, 2000).

The growth of developmental mathematics students and high failure rates of developmental mathematics students have community colleges searching for ways to decrease these failure and promote lifelong learning. Noel-Levitz (2008) says that educators are using integration of technology into developmental mathematics courses as a way to raise the pass rates of students. Johnson and Aragon (2000) encourage learning environments to be comprised of behavioral, cognitive, and social learning theory. Computer-assisted instruction can provide an environment that promotes these theories, while at the same time supporting the key concepts of adult learning theory.

The crisis in remedial course completion and its impact on college retention, persistence, and completion presents an opportunity for further research into initiatives that demonstrate significant ability to improve the remediation process. Best practices that utilize innovative classroom pedagogies and course delivery formats may hold the key to moving students out of remedial courses and into college-level work more quickly, thus giving them a clear path to reach their educational goals (Rutschow & Schneider, 2011).

The findings of this study may also serve to inform developmental mathematics instructors and administrators of the effectiveness of the emporium model, as many institutions move to implement redesigned developmental mathematics curricula that emphasizes open entry and exit, accelerated delivery, and the increased use of technology as a teaching tool. In an era when improving academic success, persistence, retention, and completion has become a priority, any information that relates to these topics is useful.

Delimitations and Limitations

The following delimitations may have impacted this study:

- One delimitation of this study relates to the population being studied. The study was limited to remedial mathematics students enrolled at a large, southern, urban, multi-campus community college. The results may not be generalized to other courses or non-remedial students at different types of institutions.
- This study utilized logistic regression to identify any possible relationships between the independent and dependent variables. The logistic regression statistical model is considered a non-experimental design, so it is unable to prove a causal relationship between variables. Rather, such a study can only answer questions about whether group differences exist. There is no establishment of causality or manipulation of variables. The goal is to provide an overall picture of a phenomenon, and not to examine the degree or types of relationships between the variables (Huck, 2012).
- This study only examined developmental math courses, and not other developmental courses such as English.
- Age, gender, ethnicity, financial aid status, employment status, and length of employment were the only contextual variables that were examined in this study.
- Only one method of developmental math instruction, the emporium model, was compared to traditional developmental math courses. Other modifications to

developmental math courses, such as different session lengths or hybrid delivery formats, were not examined.

The following limitations may have impacted this study:

- A key limitation concerned the differences in both instructional strategies and teaching styles of each instructor, which may explain any observed differences in the dependent variables.
- Another limitation concerned the use of archival data. Archival data were collected by someone else and may not include all information for every participant in the study. This may result in specific participants having been dropped from the study. Archival data and student reporting of age and ethnicity could not be verified.
- Only one computer software package was used in this research study. This study was limited to examining MyMathLab, as it was selected by the institution being studied. Other software programs may have provided different results.
- Students, with limited experience using computers, may have been anxious about taking the emporium model course, and this anxiety could have resulted in poor performance in the class. To minimize this reaction, a thorough tutorial was provided on the use of the software program, and the instructor for the course was available during class sessions to provide assistance when necessary.
- Computer access, for students who did not own computers with internet connections, may have been an obstacle for completing assignments on time.
- Random assignment into control and experimental groups was impossible, due to the *ex post facto* nature of the study.

- The final exam used to gather data for this study was constructed by instructors and therefore could have been biased. The test included basic problems that students needed to master in order to move to the next mathematics course.
- Another limitation was the unknown factor as to why some students drop and fail courses, since withdrawals and failures can reflect more than not mastering the material in the way it was delivered. Issues influencing a decision to withdraw may include work/life balance, caregiving responsibilities, access to support outside of school, and student motivation.
- There are limitations to using ACCUPLACER test scores for placement into developmental math classes. ACCUPLACER test scores may not accurately provide a measure of academic preparedness, and thus some students may have been incorrectly placed into a developmental math class.
- Participants in this study were limited to those students who enrolled in developmental mathematics courses during the spring 2011 semester.
- Students were able to access the following range of services:
  - Tutoring by appointment
  - Drop-in tutoring
  - Academic workshops focusing on topics such as test-taking skills, note-taking skills, study skills, and time management
- Sample size may have been a limitation. The research study covered enrollment for a spring semester; fall semester registration is generally higher. The use of a small sample size requires caution when interpreting results and attempting to

generalize them to a larger population; the results shown here may have just been unique to the institution under study.

- Extraneous variables such as math anxiety, personal demands, student attitudes, and motivation were not examined because archival data on these variables was not available.
- The data came from an urban community college located in the southeastern United States. Therefore, it may prove difficult to generalize the results to an institution of a different size, one located in a different geographic location, or one that contains a substantially different population in terms of student demographics.

Assumptions and Conditions

- The curriculum delivered by the MyMathLab in the emporium model classes was assumed to be aligned with the curriculum that was being used in the lecture format classes.
- This study assumed accurate placement into a developmental mathematics course sequence based on placement test scores.
- Instructors at the college who taught in the emporium model format were assumed to have received training on instructional techniques, as well as the software used.
- All instructors were assumed to have administered the same final exam.
- All learning outcomes were assumed to have been met regardless of instructor or instructional approach.
- Knowing that demographic information is self-reported by the student, the demographic information of the students was assumed to be accurate.

Definitions and Abbreviations

- Retention: Re-enrolling continuously from the fall semester of one academic year to the next (National Center for Education Statistics, 2014) (This definition is connected to a variable of interest in this study).
- Retention rate: Defined as the rate, expressed in percentage, at which students continue their college enrollment from the fall semester of one academic year to the next (National Center for Education Statistics, 2014).
- Persistence: Re-enrolling continuously from one academic term/semester to the next (Grunder, & Hellmich, 1996) (This definition is connected to a variable of interest in this study).
- Persistence rate: The rate at which students at all levels of an institution achieve expected academic progression when moving from one academic term/semester to the next (National Center for Education Statistics, 2014).
- Student success–College transfer: Successfully transferring to a two- or four-year college institution within 150% of normal time (National Center for Education Statistics, 2014) (This definition is connected to a variable of interest in this study).
- Student success–Completion: Successfully completing a curriculum terminal degree, diploma, or certificate within 150% of normal time (National Center for Education Statistics, 2014) (This definition is connected to a variable of interest in this study).
- Developmental mathematics course - Completion: Completion of a course with a grade of A, B, C, or Pass on first attempt (National Center for

Education Statistics, 2014). Course policy of the institution under study requires completion of a remedial course with a final grade of C, Pass, or better (This definition is connected to a variable of interest in this study).

- Completion–Gateway curriculum mathematics course: Completion of a gateway curriculum mathematics course with a grade of A, B, C, or Pass on first attempt (National Center for Education Statistics, 2014) (This definition is connected to a variable of interest in this study).
- Student: Defined as a student whose success, persistent, retention, and completion data are being analyzed as part of this study (This definition is connected to a variable of interest in this study).
- Student demographics: Defined as student age, gender, ethnicity, and financial aid status (This definition is connected to a variable of interest in this study).
- Course format: Defined as either traditional lecture format or emporium format (This definition is connected to a variable of interest in this study).
- Course instructor: Defined as the identified instructor assigned to teach a specific class section that is part of this study (This definition is connected to a variable of interest in this study).
- Course instructor demographics: Defined as employment status and length of employment (This definition is connected to a variable of interest in this study).
- Traditional lecture instruction: Teacher-directed, lecture based and textbook based instruction involving no computer use (Cotton, Marshall, Varnhagen, & Gallagher, 1979). Lecture instruction most often involves a process by which

the teacher presents new topics to the class via a presentation model, addresses any questions that students may have about the new or previously presented topics, and then finishes by assigning homework focusing on the new topic (Teal, 2008).

- Developmental education: Developmental education is an umbrella term referring to underprepared college students and the courses and services developed to serve them. The National Association for Developmental Education (2013) defines developmental education as a series of programs and services intended to address the issues of academic preparedness, assessment and placement, and learning strategies for general studies and specific disciplines. Developmental mathematics is a branch of developmental education designed to provide instructional and support necessary to prepare students for college-level mathematics coursework (Armington, 2003).
- Emporium course format: In the emporium model, teachers serve in the role of facilitator and tutor, not lecturer. The goal is to promote more one-on-one teacher/student interaction, with the student becoming a more active learner. By assessing what they do and do not know, they are able to either remediate via access to resources, or accelerate their instructional pace as their capabilities allow (National Center for Academic Transformation, 2012a).
- Computer-assisted/aided instruction: Software takes over the traditional role of instructor. The software provides lecture materials, provides guided, interactive feedback, and administers assessments (Price, 1991).

- MyMathLab: An online interactive mathematics software program developed by Pearson Education. MyMathLab allows students to master mathematics concepts by providing modularized, self-paced instruction through the use of online homework, quizzes, and multi-media learning aids such as videos and animations (Pearson Education, 2014). MyMathLab was the computer software used in the emporium classrooms at the institution investigated in this study.

Organization of the Study

This study consists of five chapters. Chapter I introduces the study and includes the following sections: overview, need and purpose, statement of the problem, research questions, research design, study significance, delimitations and limitations, assumptions and conditions, definitions and abbreviations, organization of the study, and summary. Chapter II includes a comprehensive literature review. Chapter III includes the methodology that was used in the study. Chapter IV includes the participant and procedure summary, as well as results of the study. Finally, Chapter V includes a discussion of the results, recommendations for policy/practice, and recommendations for future research.

Summary

Remedial mathematics instruction is an area that could benefit from improvement. Developmental mathematics students struggle to pass the classes that are designed to prepare them for enrollment into college-level math courses (Melguizo, Hagedorn, & Cypers, 2008). If a student cannot increase retention and achievement in lower level courses, many will drop out of college and forfeit lifetime dreams. Studies indicate there is some evidence to show that computer-assisted instruction enhances retention and achievement in developmental mathematics students. Taylor (2008) found that computer-mediated instruction did not significantly improve student attitudes but did improve mathematical achievement. Olusi (2008) compared computer-assisted instruction with traditional instruction and concluded that computer-assisted instruction was more effective. The inconclusive nature of current research creates an opening for more work in this area.

Colleges are spending money to purchase technology in an effort to provide students and instructors with the instructional technology that is intended to produce better results in developmental mathematics courses. Mathematics instructors are sometimes reluctant to integrate technology into the curriculum and instruction (Swan & Dixon, 2006). This study attempted to provide mathematic instructors with evidence on whether or not the combination of an emporium model course delivery format and computer-assisted instruction may predict developmental mathematics success, persistence, retention, and completion.

This research will help to determine whether the emporium model computer-assisted learning is an appropriate and effective way to redesign the learning environments of developmental mathematics courses, as a means to improve student achievement. Record enrollment at two- and four-year institutions, and consistently high failure rates in remedial courses as well as gateway courses, demonstrate the necessity to drastically redesign those courses. Past modification of these courses by simply supplementing with technology has made very little progress. The advancements in technology and instructional software make substantive, emporium-based redesign efforts possible.

Information obtained from this research may help educators and administrators of two-year institutions in planning and implementing a course redesign to boost student academic success, persistence, retention, and completion in developmental mathematics courses.

CHAPTER 2: LITERATURE REVIEW

Overview

Students seeking to earn a postsecondary degree are increasingly finding successful completion of developmental mathematics courses to be an academic barrier (Boylan & Bonham, 2007; Jones, 2012). Creating new classroom options, which assist students to complete a developmental education course sequence in a faster timeframe and with improved mastery, may be one solution to this challenge (Charters, 2013).

Instruction utilizing computer-assisted technology is being implemented at many community colleges as one solution to these issues, but it poses a number of new opportunities and challenges for developmental education instruction (Bahr, 2008). Even though developmental mathematics has been in place at many community colleges for decades, a review of current literature reveals few definitive studies on the efficacy of specific instructional models targeting remedial populations (Hodara, 2011).

This study investigated whether exposure to a newly implemented developmental math course delivery format, the emporium model, improves student success, persistence, retention, and completion rates in both developmental and college-level mathematics courses. Based on the literature reviewed, chapter two was organized into the following central themes under the overall heading of issues impacting academic success, persistence, retention, and completion for students who; 1) enrolled in developmental and college-level mathematics courses in a community college setting, and 2) utilized the emporium course delivery format for their developmental mathematics instruction: (a) The history and historical challenges of developmental education in community colleges; (b) Pressure to improve persistence, retention, and completion in developmental education mathematics courses; (c) Traditional/historical measures, barriers, and facilitators of academic success for developmental education students; and, (d) Emporium delivery format and developmental education mathematics courses. These themes are summarized in Table 2.

Table 2: Identified Issues Impacting Academic Success, Persistence, Retention, and Completion

Issue	Sources
The history and historical challenges of developmental education in community colleges	Adelman, 2006; American Association of Community Colleges, 2012a; Armington, 2003; Attewell et al., 2006; Bahr, 2008; Bailey & Cho, 2010; Bettinger, & Long, 2004, 2009; Boughan, & Clagett, 2008; Boylan, 1983, 1995, 1999; Brothen & Wambach, 2004; Brown v. Board of Education, 1954; Brubacher & Rudy, 1997; Casazza, 1999; Committee on Measures of Student Success, 2011; Day & McCabe, 1997; Dellow & Romano, 2002; Dotzler, 2003; Education Commission of the States, 2002, 2014; Ewell, 2011; Fain, 2013; Flannery, 2014; Gerlaugh, Thompson, Boylan, & Davis, 2007; Grable, 1988; Hassel, Klausman, Giordano, O'Rourke & Roberts, 2015; Hennessy, 2002; Hodara, 2011; Kolajo, 2004; Kozeracki, 2002; Lapez, 2014; Marra, 2014; Maxwell, 1979; McCabe & Day, 1998; McCabe, 2000; Michigan State Board of Education, 1990; Mills, 1998; Moore, Jensen, & Hatch, 2002; NADE, 2013; Noel-Levitz, 2008; Ohio Association of Community Colleges, 2013; Pascarella & Terenzini, 2005; Percy & Smith, 1982; Roueche & Roueche, 1999; Rueda & Sokolowski, 2004; Schuyler, 1999; Stigler, Givvin & Thompson, 2010; The Carnegie Foundation for the

(continued)	Advancement of Teaching, 2008; The Institute for Higher Education Policy, 1998; Trenholm, 2006; Waycaster, 2011
Pressure to improve persistence, retention, and completion in developmental education mathematics courses	Bontekoe, 1992; Boyd & Others, 1988; Boylan, 2008; Boylan, Bliss, & Bonham, 1997; Bridgeman, 1982; Capps, 1984; Carnegie Foundation for the Advancement of Teaching, 2008; Castator & Tollefson, 1996; Chung, 2005; Clery, 2006; Cohen, 1987; Cox, 1990; Dumont & Others, 1981; Dumont, Bekus, & Tallon, 1981; Dwinell, 1985; Dyer, Reed, & Berry, 2006; Edgecombe, 2011; Fong & Visher, 2013; Gash, 1983; Goldston, 1983; Grable, 1988; Hiebert & Grouws, 2007; Higbee, Arendale, & Lundell, 2005 ; Hodara, 2011; Hughes & Nelson, 1991; Institute for Higher Education Policy, 1998; Jacobson, 2006; Johnson, 1981; Jones, 1986; Kinney & Robertson, 2003; Koch, 1992; Kozeracki, 2002; Levine, 1990; Lipika & Lieberman, 2013; Lipsett, 1986; Lovell & Fletcher, 1989; Maxwell, 1991; McCabe & Day, 1998; McCoy, 1991; Noel-Levitz, 2008; Parker, 2007; Percy & Smith, 1982; Porter, 1988; Pounds, 1981; Pretlow & Wathington, 2012; Quint, et al., 2011; Reddy, 1985; Roueche, 1981; Roueche, 1983; Rounds & Andersen, 1985; Saade, 2003; Slavin & Karweit, 1985; Stuart, 2009; Tarrant County Junior College, 1984; Taylor, 2008; Trenholm, 2006; Weissman, Bulakowski, & Jumisko, 1997; Wepner, 1985; Sinclair Community College, 1994; Zwerling, 1980
Retention rates in developmental education mathematics courses as predictors of success in credit-bearing courses	Bragg, 2001; Cohen & Brawer, 2008; Hadden, 2000; Hiebert & Grouws, 2007; Levine, 1990; Lucas & McCormick, 2007; Mayer et al., 2014; Quint, Jaggars, Byndloss, & Magazinnik, 2013; Stigler, Givvin, & Thompson, 2010; Townsend 2000, 2001
Traditional/historical measures, barriers, and facilitators of	Achieving the Dream & Jobs for the Future, 2010; Attewell et al., 2006; Bahr, 2007, 2008, 2009; Bailey et al. 2010 ; Bailey, Jeong & Cho,

(continued) academic success for developmental education students	2010; Boatman & Long, 2010; Boylan & Bonham, 2011; Bragg, 2001; Capps, 1984; Cohen & Brawer, 2008; Cohen, 1995; Collins, 2009; Cox, 1990; Diaz 2010; Dougherty, 1994; Edgecombe, 2011; Epper & Baker, 2009; Erickson, 2013; Fong & Visher, 2013; Grable, 1988; Hadden, 2000; Hodara, 2011; Hughes & Nelson, 1991; Jacobson, 2006b; Jenkins et al., 2009; Johnson, 1981; Johnson, 1996; Jones, 1986; Koch, 1992; Kohler, 2012; Konkel, 2014; Kuh, Kinzie, Buckley, Bridges, & Hayek, 2006; Maxwell, 1991; Mayer et al., 2014; McCusker, 1999; NADE, 2013; Nawrocki et al., 2009; Percy & Smith, 1982; Quint et al., 2011; Quint, Jaggars, Byndloss, & Magazinnik, 2013; Rotman, 2012; Roueche, 1981, 1984; Rounds & Andersen, 1985; Rutschow, 2011; Shaw & London, 2001; Slavin & Karweit, 1985; Tinto, 1987, 1993, 2006; Townsend, 2001; Vallade, 2013; Vandal et al., 2010; Worden, 1984; Zwerling, 1980
Academic success of developmental education students in subsequent credit-bearing courses	Bahr, 2007; Boylan, 1995, 2002; Hector, 1983; Levine, 1990; Porter, 1988; Wepner, 1985
Emporium delivery format and developmental education mathematics courses	Cross, 1976; Epper & Baker, 2009; Golfin et al., 2005; Kinney & Robertson, 2003; Kozeracki, 1999; Lesh & Rampp, 2000; Marx, 2006; Merseth, 2011; Miller, Pope, & Steinmann, 2005; Perez & Foshay, 2002; Phipps & Merisotis, 1999; Simms & Knowlton, 2008; Spradlin & Ackerman, 2010; Taylor, 2008; Thiel et al., 2008; Tucker, 2002 ; Vallade, 2013; Van Campen, Sowers, & Strother, 2013; Young, 2005; Zhu & Polianskaia, 2007
Emporium delivery format and impact on academic success, persistence, retention, and completion of developmental mathematics students	Adams, 2003; Bargagliotti, Botelho, Gleason, Haddock, & Windsor, 2012; Bendickson, 2004; Berryman & Short, 2010**;** Boylan & Bonham, 2011; Boylan, 2011; Buzzetto-More & Ukoha, 2009; Charters, 2013; Cohen, 1995; Eckart, 1984; Epper & Baker, 2009; Erickson, 2013;

(continued)	Hern, 2010; Hodara, 2011; Jacobson, 2006a; Kinney & Robertson, 2003; Kinney et al., 2004; Kulik & Kulik, 1991; LaManque, 2009; Maynard, 1983; McMillan et al., 1997; National Center for Academic Transformation, 2012a; National Center for Academic Transformation, 2012b; Robinson, 1990; Schwartz & Jenkins, 2007; Seal, 2008; Sharma, 1980; Spradlin & Ackerman, 2010; Squires, Faulkner, & Hite, 2009; Stewart, 2012; Taylor, 2008; Thiel et al., 2008; Toet, 1991; Trenholm, 2009; Twigg, 2011; Vallade, 2013; Vandal et al., 2010; Zavarella & Ignash, 2009; Zhu & Polianskaia, 2007

The History and Historical Challenges of Developmental Education in Community Colleges

Developmental education in the postsecondary college setting has faced many historical challenges. These challenges have revealed themselves acutely in the most popular of developmental education course offerings–mathematics.

The issue of skill remediation for college-bound students is not a new phenomenon. Debates regarding the need for such remediation and the best way to implement it, have been on-going since colonial times, when institutions such as Harvard and Yale required students to demonstrate proficiency in foundational subjects–such as languages and mathematics - as part of their entrance exams. Students who needed supplemental instruction when preparing for these examinations sought out the assistance of personal tutors or the local clergy (Brubacher & Rudy, 1997).

This model of postsecondary education experienced its most significant changes after World War II, with the influx of college students stemming from the Servicemen’s

Readjustment Act of 1944 (the GI Bill). The legislation allowed millions of returning soldiers to enroll in college, beginning in the fall of 1946 (Brubacher & Rudy, 1997; Casazza, 1999; Dotzler, 2003). Suddenly, higher education was no longer a privilege for the wealthy few. It had become an attainable goal for practically all sectors of society. These new adult learners began to academically outperform their younger classmates - enrolled under traditional admissions processes - and showed the potential for academic success among adult populations who were motivated and given a second chance (McCabe & Day, 1998). The unprecedented numbers of students seeking a college education during this time helped to lay the groundwork for the establishment of additional community colleges, driven in part by the recommendations of the President's Commission on Higher Education in 1947 (Brubacher & Rudy, 1997; Maxwell, 1979).

Another important milestone in the growth of postsecondary educational opportunities for Americans occurred with the Civil Rights Movement of the 1950s and 1960s, which saw segregation declared unconstitutional and a move toward integrating U.S. educational institutions at all levels (Martin, 1998).

The argument for an expanded and standardize mathematics requirement in colleges gained new urgency with the United States/Russia space race, which began with the launch of the Sputnik satellite in 1957. The Sputnik launch in particular spurred the U.S. Congress to pass the National Defense Education Act of 1958. This legislation boosted postsecondary education by making low-cost educational loans available to students and by funding expansion of mathematics, science, and language programs at colleges and universities (Clowse, 1981; Hennessy, 2002).

As the demographic bulge of the Baby Boom generation worked its way through four-year colleges and universities beginning in the early 1960s, an opportunity opened up for community colleges. These institutions had earlier adopted open access/open admissions policies, which made them the perfect option for prospective college students who were seen as either academically underprepared by their first college choice, or who did not have the financial means to pursue a traditional four-year college path (Boylan, 1995).

As more and more students chose the community college path, these institutions began to look for programs and interventions that would help the underprepared portions of their student populations to succeed. Their goal was to balance the core open access mission, with the need to ensure that appropriate academic standards were being maintained for all student populations (Casazza, 1999). This tension between access and academic rigor is what ultimately led to the creation of the remediation initiatives that would later become known as developmental education (Boylan, 1995).

The National Association for Developmental Education (NADE) defines developmental education as a discrete instructional discipline within postsecondary education that “promotes the cognitive and affective growth of all postsecondary learners, at all levels of the learning continuum” (2013, para. 3). This is accomplished through academic preparedness activities, assessment and placement testing, diversification of learning strategies, and research into learning barriers (NADE, 2013). By using focused interventions, developmental education assists underprepared students in completing their postsecondary education goals (Boylan, 1999).

Along with remediating students who are seeking terminal two-year degrees, community colleges have also become the remediating service of choice for four-year institutions, via the growth in the popularity of college-transfer options at many community colleges (Bettinger & Long, 2009).

State legislatures across the United States tightened public education budgets as a result of the recent recession (Altstadt, 2012). Politicians involved in this work began to question the usefulness of providing public funding for developmental education courses taking place at public colleges (Vallade, 2013). Their argument centered on the concept of expecting taxpayers to fund a service twice–once when students complete college preparatory classes in a public high school and again when these same students are placed in developmental courses at the community college because they fail to demonstrate college readiness on placement exams (Bahr, 2008; Bracey, 1999; Pretlow & Wathington, 2012). Educators have also questioned the role that developmental education coursework plays in watering down academic standards, devaluing postsecondary credentials in general, and demoralizing college faculty who find large numbers of their students cannot academically perform at the college level (Bahr, 2008). The response to these arguments has been that developmental education courses serve an essential need, as they (a) provide a remedial opportunity for students who may have attended inadequate K-12 schools through no fault of their own and (b) provide a vital refresher on concepts that adult students - returning to the classroom after many years - may have long since forgotten (Roueche & Roueche, 1999). Researchers have also stated that we should not expect the majority of high school students to be prepared for college-level work, citing studies that nearly two-thirds of high school students will attempt college, but only 50% will have taken college preparatory courses (Boylan, 1999).

These important issues highlight a key attribute of developmental education; it is focused on ensuring all students are equipped with the skills and knowledge necessary to succeed at the college level, thereby creating equality of opportunity among those who may have been either advantaged or disadvantaged in their earlier academic experience (Mills, 1998). By creating this even academic playing field, developmental education minimizes the number of students who may have otherwise faced limited job prospects and the limited socioeconomic opportunities that often go with them (Roueche & Roueche, 1999).

According to Day and McCabe (1997), the complexities of our modern society require individuals to possess college-level competencies in the areas of mathematics, writing, and reading if they wish to be full and successful societal participants and partake of the opportunities modern society offers. College graduates provide numerous tangible benefits to society, including lower rates of criminal behavior and increased rates of community activism as compared to the overall population (Pascarella & Terenzini, 2005).

The cost of providing developmental education services at community colleges throughout the United States has been estimated at more than $1 billion annually (Bailey & Cho, 2010; Kolajo, 2004). This investment is driven by the fact that 75% of students enrolling into community colleges place into one or more developmental courses. This equates to approximately three million students a year taking one or more remedial courses. Of those who place into a mathematics course, failure rates for first attempts range between 35% and 42% (Noel-Levitz, 2008). But other studies have put the passing rate for developmental mathematics courses as low as 30%, thus calling into question the validity of these numbers, and how they were calculated (Attewell et al., 2006). Another study by Gerlaugh, Thompson, Boylan, and Davis (2007) showed a 68% passing rate for developmental mathematics students, but the study did not count students who dropped or withdrew.

NADE took an early lead in researching and promoting best practices in the field of developmental education, particularly in the field of mathematics. One study conducted by NADE focused on cataloging developmental mathematics education teaching and support strategies that demonstrated the greatest effect on student academic success. The result was a list of best practices including: implementation of tutoring and other support services to reduce math anxiety, actively confronting student myths regarding the difficulties of learning math, making placement test study sessions mandatory prior to first attempt, and utilizing technology to make mathematics learning materials available to students on-demand as needed (Armington, 2003). Another study sponsored by NADE also looked at remedial programs in 14 community colleges in the United States. It found significant academic gains for students who successfully completed one or more remedial courses, as compared to other underprepared students who did not enroll in remedial courses. The remediated students also performed better on standardized tests than other students who were deemed college-ready based on their placement test scores (Boylan, 1983). Boylan's findings are also reflected in other studies which revealed cases where remediated students were able to achieve academic success and persistence levels similar to student populations who placed directly into college-level courses (Porter, 1988; Wepner, 1985). These findings are important to note here because they provided guidance for future research by showing that access to developmental courses may not only help underprepared students to catch up to their peers, but may also provide a method for them to excel beyond the baseline set by their college-ready peers.

If successfully remediated, community college students can achieve academic success and persistence comparable to students who do not need remediation (Porter, 1988; Wepner, 1985), then improving the remedial programs completion rate of these students becomes the next issue to address.

The need for comprehensive research identifying effective developmental education retention, persistence, and success strategies is being driven by the continuous rise in the number of students being placed into a developmental education track, as well as the costs associated with these remedial activities. As the number of students placed into developmental education courses continues to rise, these course sequences become a primary barrier to completion of a postsecondary degree, thus portending significant consequences for the student's future employability in an economy that offers few opportunities for those without a college degree (Stigler, Givven, & Thompson, 2010). According to Bahr (2008), there are few existing research studies evaluating developmental education program that encompass multiple institutions or are methodologically sound. In addition, deficiencies have been identified in the manner by which individual states report the progress and success of remedial students as they work through course sequences. These issues have limited the ability of community colleges across the United States to share best practices for serving remedial audiences (Education

Commission of the States, 2014). The Institute for Higher Education Policy (1998) identified efforts to research effective developmental education initiatives as under underfunded and sporadic. The Institute found that very few colleges conduct any type of comprehensive, systemic evaluation of the remedial programs, with results from the few existing research studies inconclusive (Institute for Higher Education Policy, 1998). In addition, there is a lack of information regarding what, if any, effect a developmental education course sequence has in ensuring students remain in college and complete their academic goals (Moore, Jensen, & Hatch, 2002). The timeframe employed by the majority of existing developmental education studies covers a maximum of four years (McCabe, 2000). Such a timeframe does not accommodate part-time learners who may take much longer to complete a degree.

Most existing developmental education research is limited in some form, but a few studies, in particular, have provided meaningful insight into the effectiveness of developmental education programs within community colleges. One study revealed that students who enrolled and successfully completed a developmental education English/reading course sequence had a higher likelihood of graduating, as compared to students who did not require any remediation in English/reading. The group of remediated students also performed at the same academic level as the non-remediated students (Attewell. 2006). Another study focused on students enrolled in a four-year school, and found that students who enrolled in a remedial course sequence were only slightly less likely to complete their degree when compared to the non-remediated student cohort (Bettinger & Long, 2004). A later study by Bettinger and Long (2009) found a higher persistence rate among students who completed a developmental education course sequence and then completed a four-year degree, as opposed to students with the same four-year degree goal who did not complete a developmental education course sequence.

Recent studies of remedial courses in community college settings reveal that the more developmental education courses students are required to take, the less likely they are to earn a degree (Brothen & Wambach, 2004; Kozeracki, 2002). A 2008 study by the Carnegie Foundation for the Advancement of Teaching found that 25% of students who begin their college experience by enrolling in a developmental reading course end up enrolling in a college-level course. The rate dropped to 10% for students who began in a developmental education mathematics course and then enroll in a college-level mathematics course.

The 2008 developmental education study by Bahr stands out for its comprehensiveness (Vallade, 2013). Working with data collected from 85,894 first year (i.e., freshman) college students at 107 community colleges in the state of California, Bahr used a multi-nominal logistic regression to analyze the effect of exposure to developmental education mathematics courses on the students' academic success, with success defined as earning a passing grade in a college-level mathematics course within the six year period of the study (Bahr, 2008). The study followed students for the six year period and analyzed more than a dozen variables, including age, race, gender, English competency, persistence, and enrollment inconsistency. The study determined that academic success for the students completing a prescribed developmental education mathematics course sequence was equivalent to students who did not complete any remedial courses (Bahr, 2008). The caveat noted by Bahr was that the successful students were the ones who completed the entire sequence of developmental education mathematic courses they were prescribed.

The Institute for Higher Education Policy (1998) and the Education Commission of the States (2002) both reported on a study of community college graduation rates that revealed 60% of students who never took a developmental education course completed their degree, versus a 35% graduation rate for students who took five or more developmental education courses. Another study found that approximately half of students enrolled in a developmental education course earned a four-year degree, compared to 70% of students who did not place into remedial classes (Adelman, 2006).

As the above information reveals, a comprehensive review of current research in the field of postsecondary developmental education can find point/counterpoint arguments on a range of efficacy issues. Results from a number of studies show that, for those student populations who persisted and completed a prescribed course sequence, not only are overall GPAs higher, but success in college-level courses is comparable to those who never had to take a remedial course (Brothen & Wambach, 2004; Waycaster, 2011). These results can be countered by those who cite low completion rates for both single courses as well as prescribed course sequences, along with low student morale (Brothen & Wambach, 2004; Hodara, 2011).

There is an additional dimension overlaying this discussion of developmental education and its historical impact on the ability of students to complete a prescribed program of study. This dimension focuses on the debate regarding exactly what it means for a student to “complete” in a community college environment. The dominant, current national tracking mechanism for determining rates of student completion at postsecondary institutions is the Graduation Rate Survey (GRS).

The GRS was developed following the 1990 passage of federal legislation known as the Student Right to Know Act, which requires postsecondary institutions to report graduation rates for first-time, full-time students who are enrolled in curriculum degree or certificate programs of study. Information gathered from institutions via the GRS is collected by the National Center for Education Statistics (NCES), and then reported nationally via the Integrated Postsecondary Data System (IPEDS) operating under the auspices of the U.S. Department of Education (Dellow & Romano, 2002). The reporting benchmark for the GRS is completion of a selected program of study within 150% of traditional time. For two-year degrees, this equates to three years. Because of their nationwide availability, GRS data are often used by state and local educational agencies, as well as college leadership, to gauge and compare student success rates both within and between similar institutions (Ewell, 2011).

When viewed in the context of two-year institutions, GRS data have been identified as an unsuitable measure of institutional effectiveness. Specifically, community college students have widely differing enrollment patterns and goals. Some seek to pursue a degree, while others want an industry-focused certificate or credential. Others seek to transfer to a four-year institution, or are simply taking a single course as part of their employer's contract training agreement with the local community college. Still other students are taking courses simply for the satisfaction of lifelong learning (Boughan & Clagett, 2008; Committee on Measures of Student Success, 2011).

The result of this is that current student success and completion data for community colleges may be seen as having validity issues, due to the fundamental mismatch between the GRS research methodology as currently employed, and the reality of why students decide to enter and leave community colleges.

As part of the movement to make the GRS a more effective instrument for tracking student success and completion for community college cohorts, the Committee on Measures of Student Success (CMSS) has recommended a series of improvements to the GRS. These include expanding reporting of specific student populations at two-year colleges; in particular, distinguishing between remedial and non-remedial students (Committee on Measures of Student Success, 2011). Community colleges themselves are also pursuing alternatives to the GRS through incumbent initiatives such as the Voluntary Framework for Accountability (VFA), which includes reformulated student success measures that better reflect the missions of community colleges, as well as the goals students have for attending the institutions (American Association of Community Colleges, 2012b). As compared to the GRS, the VFA gauges student progress through many outcomes, including remedial courses, academic progress, college transfer, and workforce-specific outcomes for those seeking career and technical education training (Lapez, 2014). These changes are the first wave of what may become a series of updated accountability models that will provide a more accurate picture of how remediation affects a student's planned academic pathway through an institution.

Looking to the future, policy initiatives currently underway in various U.S. states underscore the on-going pressures and challenges that developmental education programs in the community college setting may continue to face. Connecticut has implemented an accelerated format for all developmental education instruction, and requires that such remedial assistance be embedded within credit-bearing courses. Developmental education support has also been limited to one semester (Hassel, Klausman, Giordano, O'Rourke, & Roberts, 2015). Colorado now offers developmental education as a co-requisite for credit-bearing courses. This model is also being considered by West Virginia and Ohio (Flannery, 2014; Marra, 2014; Ohio Association of Community Colleges, 2013). In addition to the changes mentioned later in this chapter, Tennessee has encouraged high-school students to complete developmental math courses before they apply to a community college (Hassel, Klausman, Giordano, O'Rourke, & Roberts, 2015). Finally, Florida has enacted legislation making developmental education courses optional for students who recently graduated from a high school within the state. Students who select a remediation option may complete it while concurrently enrolled in college-level courses (Fain, 2013). When taken together, these recent developments may be seen as evidence that the future trends within developmental education point toward continued efforts at improving success, persistence, and retention rates, accelerating completion timeframes, and reducing program costs.

This section of the literature review provided an overview of the history and historical challenges of developmental education programs in community colleges. Efforts to improve student academic performance through remediation activities have been on-going since colonial times, when students would seek academic assistance from tutors and the local clergy (Brubacher & Rudy, 1997). The need to provide college education opportunities to soldiers returning from World War II helped lay the groundwork for modern community colleges (Casazza, 1999; Dotzler, 2003). This was further emphasized by the cultural trends stemming from the Civil Rights Movement, the national focus on math and science training as part of the United States/Russian space race, and the Cold War (Clowse, 1981; Hennessy, 2002; Martin, 1998).

As the broad demographic groups resulting from these events and cultural trends sought a college education at community colleges, officials began to notice huge gaps in their academic preparedness, and began instituting remedial courses in foundational concepts such as math, English, and reading. These courses would later evolve into the modern developmental education curricula (Boylan, 1995). According to the National Association for Developmental Education (2013), developmental education programs today serve an important need by ensuring all students are equipped with the skills and knowledge to success at the college level. This ensures equality of opportunity for students across the socioeconomic spectrum. Developmental education is being challenged today through funding constraints from state legislatures, and from the large number of students who place into a developmental education course sequence when applying to community colleges.

To confront these challenges, NADE has published studies identifying developmental education best practices that support improved student academic success. These best practices included embedded academic support and the use of technology to make learning materials available to students in an on-demand format. Students who were remediated in classes following these guidelines performed at levels similar to students who placed directly into college-level courses (Boylan, 1983). The pressure to improve persistence, retention, and completion is another primary challenge to developmental education programs in community colleges. It has been shown that very few community colleges conduct comprehensive and systematic evaluations of their developmental education programs. Further, external studies focusing on persistence, retention, and completion in developmental education programs may be seen as inconclusive due to a lack of sound research methodology (Bahr, 2008; Education Commission of the States, 2014; The Institute for Higher Education Policy, 1998; Moore, Jensen, & Hatch, 2002).

The research in this area is further challenged due to on-going controversies regarding the manner by which a student who works through a developmental education course sequence is counted as having completed a program of study within the community college environment. The most dominant, current method of gauging completion rates utilizes the Graduation Rate Survey (GRS). But it is seen as not accommodating the various pathways by which students needing remediation enter and leave community college programs (Committee on Measures of Student Success, 2011). In an attempt to address this issue, the Committee on Measures of Student Success (2011) has made recommendations on modifications to the GRS. In addition, the American Association of Community Colleges (2012b) has published an alternative to the GRS via the Voluntary Framework for Accountability (VFA). It is hoped that the adoption of one or both of these models may better document how remediation affects the matriculation arch for a community college student (Lapez, 2014).

Recent trends in developmental education policy changes at the state level suggest that future program modification will continue focusing on efforts aimed at improving success, persistence, and retention rates, accelerating completion timeframes, and reducing program costs (Fain, 2013; Hassel, Klausman, Giordano, O'Rourke, & Roberts, 2015; Flannery, 2014).

The findings of this literature review section support the research questions of this study by demonstrating that remedial programs in community colleges provide an important societal role through their creation of clear pathways to college degree attainment for a broad spectrum of society. But as the number of community college students needing remediation grows, these institutions are under pressure to find instructional solutions that may quickly bring these students up to the performance levels of their college-ready peers. Increasing pressures to demonstrate improvements in persistence, retention and completion rates for their entire student populations means that community college need more and better research in this area.

Pressure to Improve Persistence, Retention and Completion in Developmental Education Mathematics Courses

As the number of students taking developmental education mathematics courses has continued to rise, educators and researchers have looked for best practices capable of substantially improving existing course persistence, retention, and completion rates. A review of literature shows a consensus around recommendations that administrators in postsecondary institutions may best improve their remedial course offerings by making program changes based on evidence-driven research grounded in sound methodology and backed by generally accepted theoretical foundations (Achieving the Dream & Jobs for the Future, 2010; Boylan, 2008; Chung, 2005; Higbee, Arendale, & Lundell, 2005; Weissman, Bulakowski, & Jumisko, 1997). According to estimates developed by McCabe and Day (1998), over two million students would drop out of college each year if they did not have access to remedial education services. Effective remedial program changes should emerge from a data-driven, assessment-focused organizational culture that values evidence, and understands the impact that the teaching environment has on the nature and level of student learning (Hiebert & Grouws, 2007). The latest available meta-analysis of remedial programs reveals that few institutions assess and improve their remedial programs using such procedures (Weissman, Bulakowski, & Jumisko, 1997).

The Carnegie Foundation for the Advancement of Teaching (2008) offered a numbers of proposals for improving the efficacy of pre-college education programs, including:

- Measures to improve developmental education must be a priority institution-wide, and must be seen as a core responsibility for everyone.
- Consider policies that mandate remedial course completion early in a student’s academic career.
- Intensive professional development training must be put in pace for developmental education faculty, and must be seen as an integral part of faculty workloads.
- The institutional research function at colleges must be more focused on researching and assessing the effectiveness of teaching and learning processes.
- Better metrics for measuring the quality and pace of student learning must be developed.
- Institutions must be more intentional about sharing models and best-practices with all of their peer organizations.

Another study found a higher rate of course completion rates at community colleges where placement into developmental education courses was mandatory based on placement test scores, as compared to course completion rates at colleges without such a policy (Boylan, Bliss, & Bonham, 1997). An additional study at a four-year institution found that of the cohort of students who did not complete any needed remedial classes during their first academic year, 70% failed to graduate within the expected timeframe. Of the students who did complete needed remedial classes during that crucial first year, 69% graduated within the expected timeframe (Stuart, 2009). Research also indicates that curriculum procedures requiring students to compete remedial work either prior to or simultaneously with college-level courses creates academic success rates similar to that of students who did not need to take any remedial courses (Castator & Tollefson, 1996). These findings align with work from a number of researchers that indicates a mandatory placement approach for remedial courses has a statistically significant effect on student academic success and completion (Boylan, 2008; Kozeracki, 2002; Weissman, Bulakowski, & Jurnisko, 1997).

These recommendations build upon the findings of other researchers, who point out the need for colleges to transform how remedial mathematics is taught by modifying both curricula and delivery models so that students may more quickly complete a developmental education course sequence, as well as the importance of colleges working downstream with high schools so that fewer students are emerging from those institutions without college-ready skills (Collins, 2009; Edgecombe, 2011; Institute for Higher Education Policy, 1998; Kozeracki, 2002; Parker, 2007; Stigler, Givvin, & Thompson, 2010).

A review of research on the topic of developmental education program quality reveals a number of key metrics governing program effectiveness. These include: (a) college-level course completion rates for students who have completed a developmental education course sequence, (b) the pace at which students move from developmental to college-level courses, (c) persistence and degree competition rates for students who completed developmental education courses, and (d) student completion rates for developmental courses themselves (The Institute for Higher Education Policy, 1998; Weissman, Bulakowski, & Jumisko, 1997).

Retention Rates in Developmental Education Mathematics Courses as Predictors of Success in Credit-Bearing Courses

Enrollment in remedial mathematics courses is driven by skill gaps identified in the college admissions procedures through the use of placement testing or some other assessment of a student’s current math skill level. Assuming the goal of mathematics remediation is to eliminate this skill gap, then the assessment of course efficacy in these programs should be based on how quickly the skill gap is closed, and how well the new skill set compares to the skills of students who did not need remediation (Stigler, Givvin, & Thompson, 2010).

An unknown that continues to intrigue educators and researchers is the extent to which computer-assisted instruction may have an impact on the pace of this skills gap closure, and the quality of the new skills once they are in place (Dyer, Reed, & Berry, 2006; Kinney & Robertson, 2003; Taylor, 2008).

According to Noel-Levitz (2008), successful remedial courses begin with robust assessment and placement, and utilize an instructional model focused on individualized learning plans and multiple support interventions. For computer-assisted instruction to achieve that goal in a developmental mathematics course environment, the software itself must be reliable and efficient, and its use in the classroom must be based on sound research that clearly shows such systems have a powerful impact on student skill development, academic success, and retention (Clery, 2006; Jacobson, 2006; Saade, 2003; Trenholm, 2006).

Another body of research has looked at how a range of attitudinal, demographic and achievement factors impacted retention and completion/attrition rates for developmental education courses. These studies considered factors such as placement test scores, pre-test and post-test exam scores, age, gender, and class attendance rates. Results indicated that placement test scores, age, and pre-test exam scores were significant in predicting student retention and completion (Cox, 1990; Levine, 1990; Lipsett, 1986; Lovell & Fletcher, 1989; McCoy, 1991). The referencing of placement test scores in these results support the contention of other researchers that the mathematics ability of in-coming, high school-age developmental education mathematics students, and the degree to which they may demonstrate this ability on standardized college-preparatory exams, may be a predictor of future mathematics achievement (Dumont & Others, 1981; Pounds, 1981; Reddy, 1985). One seminal study from the 1980s looked to develop a model that could create an early warning system for identifying in-coming high school-age students at the highest risk of dropping a developmental mathematics course with the hope that such a system could help institutions make better decisions about admissions, remediation, counseling, and advising (Pounds, 1981). The study utilized the following high school assessment data as possible dropout predictors: SAT/Verbal and SAT/Math; high school GPA; high school math GPA; high school English GPA; and Basic Skills Examination-English, Reading, and Math scores (Pounds, 1981). The quantitative analysis of these variables identified SAT/Math as the best single predictor variable, correctly identifying over 80% of students who persisted through a developmental mathematics course sequence (Pounds, 1981). When combined with high school English GPA and Basic Skills Examination- Math, these three variables also correctly identified 38% of students who dropped out of a developmental mathematics course sequence (Pounds, 1981).

This section of the literature review discussed persistence, retention, and completion issues specific to developmental mathematics courses. Evidence-based research using sound methodology is recommended as the best option for community college administrators who wish to improve their developmental mathematics education programs (Achieving the Dream & Jobs for the Future, 2010; Boylan, 2008; Chung, 2005; Higbee, Arendale, & Lundell, 2005; Weissman, Bulakowski, & Jumisko, 1997). A study from the Carnegie Foundation for the Advancement of Teaching (2008) offered recommendations for improving the quality of remedial mathematics programs, and by extension, their persistence, retention, and completion rates. These included using metrics and data to drive decision-making, requiring students to take remedial courses at the beginning of their studies, and creating a climate of on-going assessment. A number of other studies also supported requiring students to take remedial mathematics courses before attempting college-level work, as well as making the remedial courses mandatory (Boylan, Bliss, & Bonham, 1997; Castator & Tollefson, 1996; Stuart, 2009). Improving the curriculum and delivery methods for developmental education mathematics courses is also seen as an area that will positively impact persistence, retention, and completion rates (Collins, 2009; Edgecombe, 2011; Institute for Higher Education Policy, 1998;

Kozeracki, 2002; Parker, 2007; Stigler, Givvin, & Thompson, 2010). Computer-assisted instruction has been investigated by a number of researchers, who laud its ability to create individualized instruction, as well as to facilitate individual interventions by faculty and teaching lab personnel (Clery, 2006; Jacobson, 2006; Saade, 2003; Trenholm, 2006). Demographic and achievement variables of incoming developmental education mathematics students have also been investigated for their ability to predict persistence, retention, and completion issues. Researchers found that placement test scores, age, and pre-test exam scores were significant in predicting student retention and completion (Cox, 1990; Levine, 1990; Lipsett, 1986; Lovell & Fletcher, 1989; McCoy, 1991).

The findings in this section are important because they demonstrate the broad reach of recent research studies looking at persistence, retention, and completion in developmental mathematics programs. Data-driven, evidence-based program improvements provide the best avenue forward for community college administrators. Program modifications that include mandatory course enrollments via placement testing, computer-assisted instruction, and individualized classroom assistance offer the best chances for improved persistence, retention, and completion rates in developmental mathematics courses.

Traditional/historical Measures, Barriers and Facilitators of Academic Success for Developmental Education Students

Beyond course persistence, retention, and completion rates, debate is on-going within the education community regarding appropriate measures of academic success rates for developmental education mathematics courses. This debate has centered on identification of barriers to, and facilitators of, academic success.

Academic success as a research concept within the college environment gained new relevancy in the 1970s, with Tinto's research focusing on the reasons why students dropped out of postsecondary institutions (Tinto, 1987). Tinto's research revealed that both the quality and quantity of student/faculty interactions had a significant predictive effect on the likelihood that college student would academically succeed in their courses, and ultimately persist to complete their academic goals (Tinto, 1987, 1993). Tinto determined that educational institutions needed to focus both on extra-curricular activities which instill a social sense of belonging, as well as classroom pedagogies that imbue the student with a sense of confidence in their own academic abilities, and a satisfaction with the academic work they perform in the classroom environment (Tinto, 1987).

Tinto's research related to academic success is particularly relevant to developmental education faculty, for their courses often align with the first year of a student's academic experience. As such, they and their courses may be seen as the gateway through which a student forms initial perceptions of the institution, receives feedback and assistance at their time of immediate academic and/or social need, and develops academic and social coping strategies that will determine their overall likelihood of academic success (Kuh, Kinzie, Buckley, Bridges & Hayek, 2006; Tinto, 1993, 2006).

This connection between developmental education courses as a student's first academic experience, and the importance of student/faculty interaction in the classroom, has been identified by NADE, which recommends that developmental education courses be built around academic and social support structures that foster a student's social and emotional, as well as intellectual, growth (NADE, 2013). Faculty/student interaction in the classroom is seen as one of the prime delivery mechanisms for these support services (Kohler, 2012).

In a recent study looking at academic success rates among identical developmental mathematics courses delivered in traditional, lab-based, hybrid, or modular formats, the results indicated a significantly higher success rate for modular format courses (Erickson, 2013). Hodara (2011) conducted a meta-analysis of literature focusing on the effectiveness of different classroom pedagogies within developmental mathematics courses. The author categorized the instructional approaches into the following categories: peer-to-peer collaboration, student awareness of their own thought processes, pedagogies for representing problems, application of course concepts, assessing student thinking, and learning delivered through technology.

Results overall were inconclusive, due to what the author characterized as a lack of methodological rigor in all of the studies reviewed. But of those studies which were determined to have used an appropriately rigorous methodology, the analysis revealed that instructional approaches using student collaboration and group problem solving offered the most promise for improving math learning and understanding (Hodara, 2011).

Another issue influencing academic success measures in the community college is the manner in which these institutions have evolved from their original academic mission as the needs of their student populations have changed. The story of college transfer is one such evolution. Upon their inception and for the first few years of their existence, community colleges focused on the transfer function, where students would take the equivalent of a fifth or sixth year of high school, and then transfer to a four-year college or university (Dougherty, 1994). Although to a lesser degree, this college transfer function is still an important part of the community college mission. In North Carolina, a revised Comprehensive Articulation Agreement (CAA) has been announced between the Community College system and the University system. This agreement facilitates the transfer of general education/liberal arts courses (Konkel, 2014). But research reveals that the college transfer patterns of today's typical community college students differ from the transfer paths anticipated by those first community colleges (Bragg, 2001).

Community colleges initially assumed college transfer would only happen in one direction; from community colleges to a four-year institution (Shaw & London, 2001), but recent research has revealed another transfer pattern. Traditional college transfer has now evolved to include the emerging trend of reverse transfer, wherein students begin their postsecondary experience at a four-year institution, and then transfer to a community college. 2009 data from the American Association of Community Colleges indicated that 1/3 of all community college students were previously enrolled at some point in a four-year institution (Moltz, 2009). So not only will students continue the original path of getting a two-year degree and then transferring to a baccalaureate institution, but they will now also move from a four-year to a two-year institution, and then back again (Townsend, 2001). The primary reasons students give for these transfer patterns include academic and financial struggles (Fain, 2012). These reasons play to the traditional strengths of community colleges, particularly their lower tuition rates and expertise in operating remedial and developmental programs. An analysis of academic behaviors associated with these transfer patterns shows that reverse transfer students demonstrate higher academic success and persistence rates than first-time community college students, and also display a higher probability of completing a baccalaureate degree (Cohen & Brawer, 2008; Townsend, 2000).

The results from the preceding paragraphs reveal that, for students seeking a postsecondary education, the college transfer option at community colleges still plays an important role in ensuring that students have access to a range of academic options to complete their academic pursuits. The nationwide push for improved completion rates in developmental education courses has focused attention on the need for faculty and administrators to research and put in place measures that will make a significant impact on persistence, retention, and completion for both individual courses and entire course sequences (Bailey, Jeong & Cho, 2010; Edgecombe, 2011;).

In researching reasons for low persistence, retention, and completion, researchers have identified multiple skill deficiencies as one factor. An example of this would be students with low levels of reading comprehension who may also have low sentence skills as a follow-on effect (Bahr, 2007).

The level of developmental course placement is another factor. Such placement promotes discouraging student attitudes-- due to the prospect of having to move through a long remedial course sequence-- and also negatively impacts the student's sense of self-efficacy and confidence (McCusker, 1999). Along with the level of course placement, the stigma that student's face in being placed into a developmental education course–and having to deal with their peer's perceptions that they are now in a group of low-ability students--also negatively impacts a student's confidence and subsequent academic performance (Hadden, 2000).

Students with these remedial needs not only face the challenges of dealing with skill deficiencies in multiple areas, but they are also placed into a stigmatized low ability group (Vallade, 2013). Such multiple barriers may serve as a possible explanation for the large numbers of students who fail to complete a prescribed developmental mathematics course sequence, but further research is needed to better pinpoint the causes (Bahr, 2007).

The issue of improved student academic performance in remedial mathematics courses has been the focus of several research studies and initiatives over the past two decades. The American Mathematical Association of Two-Year Colleges' (AMATYC) published a position paper in 1995 which outlined their proposed standards for improving mathematics education at two-year colleges and revitalizing the pre-calculus mathematics curriculum. Their standards included recommendations centered around intellectual development, content selection, and the importance of instructional strategies incorporating experiential and collaborative activities (Cohen, 1995).

Bailey, Jeong, and Cho (2010) researched the relationship between the pace of a student’s matriculation through a developmental education course sequence and their likelihood of program completion. Their study suggested accelerating the pace of developmental education studies as one measure to improve the effectiveness of the remedial system. Other research has found that the pace of developmental course completion may be increased by reducing the number of courses in a sequence, or reducing the amount of instructional content in a discrete course (Epper & Baker, 2009; Rotman, 2012).

The support structure offered by learning community cohorts has been shown to positively impact retention and academic performance of students enrolled in developmental education courses (Epper & Baker, 2009).

Finally, self-paced courses that allow students to choose their own level of academic intensity hold promise for improving academic performance by increasing the amount of time on task. Inside the classroom, this may be accomplished with technology integration that allows students to control the instructional pace, as well as mastery learning techniques that allow multiple reviews until an acceptable level of mastery is achieved. Outside the classroom, the self-paced model may be supported through supplemental instruction, or access to tutoring resources (Epper & Baker, 2009).

Overall, the recommendations of these cited studies demonstrate the possibility of research-based initiatives to increase academic achievement and student retention levels in developmental mathematics courses. Given the identified, positive correlation between academic achievement in the first attempted developmental mathematics course and a student's completion of a prescribed development mathematics course sequence, academic success, and retention initiatives focusing on that first developmental mathematics course may be the most important (Bahr, 2008).

The call for developmental education reform is being driven by the consistently high numbers of students placing into these courses, and the low numbers of student who successfully remediate in the expected timeframe. The range of acceleration strategies being tested within various institutions and organizations–which look at variables such as course sequence, content, pacing, and pedagogical approach - serve as one possible answer to this challenge. The overarching goal for all of these initiatives is to move students through developmental education as quickly as possible and into college-level work (Fong & Visher, 2013).

An initial wave of studies looking at barriers and facilitators of academic success began to appear in the early 1980s. These studies focused for the most part on quantifying success differences among students who completed remedial course sequences and those who placed directly into college-level courses. Later studies began to focus more closely on classroom practices leading to greater academic success and completion rates within remedial courses. A survey of these studies reveals a number of approaches to increase completion rates have been tried. These include modifications to the student/teacher ratio (Grable, 1988; Sinclair Community College, 1994); creation of mathematics laboratories (the precursors to emporium labs) with self-paced instruction and a mastery learning grade structure (Cox, 1990; Roueche, 1983; Slavin & Karweit, 1985); support services such as mandatory counseling, tutoring, and one-on-one supplemental instruction (Johnson, 1981; Koch, 1992; Maxwell, 1991; Roueche, 1981; Slavin & Karweit, 1985; Zwerling, 1980), and the use of instructional technologies such as multimedia and computerized instruction (Capps, 1984; Rounds & Andersen, 1985).

Studies from this time period looking at academic success practices outside the classroom include interventions focused on early placement testing for at-risk populations, along with mandatory test preparation courses (Grable, 1988; Hughes & Nelson, 1991; Jones, 1986; Percy & Smith, 1982; Rounds & Andersen, 1985).

The investigation of barriers and facilitators of academic success for developmental education students has been assisted in recent years by an infusion of support from outside organizations. Achieving the Dream was launched in 2003 by the Lumina Foundation with a goal to assist community colleges in reforming organizational cultures and adopting best practices. Achieving the Dream looks to build a culture of continuous self-examination and assessment through a systematic review of student outcomes data (Quint et al., 2011).

In 2009, the Lumina Foundation and the Bill and Melinda Gates Foundation launched the Developmental Education Initiative, which looked to focus specifically on developmental education best practices among the 15 community colleges who were then part of the Achieving the Dream initiative. An interim report on this initiative from 2011 indicated success in using a number instructional reforms and student support interventions to help students overcome barriers to developmental education course completion. These included learning communities, pairing accelerated versions of college-level and pre-college courses, curricular modularization, contextualized instruction, implementation of active/collaborative learning techniques, and classroom technology integration (Rutschow, 2011).

Follow-up reports from the Developmental Education Initiative for 2013 and 2014 found that three of the 15 participating colleges recorded developmental education success rates far above the others. These institutions were unique in that they adopted strategies that focused first on a defined student subgroup. Once the strategies were shown to work, they were then expanded to the larger student population. In addition to the instructional reforms and student support interventions listed above, these institutions also utilized placement test preparation strategies and intensive tutoring services for high-risk student populations (Mayer et al., 2014; Quint, Jaggars, Byndloss, & Magazinnik, 2013).

The body of research investigating possible correlations between enrollment in developmental education mathematics courses and subsequent academic success is inconclusive, and has revealed a range of positive, negative and neutral relationships. Participation in a developmental education course sequence can cause a student to deviate from their planned academic pathway, while expending as students’ limited financial resources (Boylan & Bonham, 2011; Vandal et al., 2010).

The work of Bailey et al. (2010) has demonstrated; (a) a negative correlation between the amount of time a student spends enrolled in remedial classes and rates of program completion for a curriculum degree, diploma or certificate, and (b) the initial level of placement within a remedial course sequence has an effect on the likelihood of sequence completion, college-level course completion, and program completion.

The pace of movement through an assigned developmental course sequence is a critical factor impacting improved academic success and retention rates (Nawrocki et al., 2009). Students who began their developmental education mathematics studies at the introductory level have been found to have lower levels of remedial course sequence completion, a lower likelihood of completing a college level- course, and lower levels of degree program completion (Bailey et al., 2010; Jacobson, 2006b).

One research study identified a relationship between the number of remedial courses taken and rates of program competition with each remedial class taken reducing the completion rate by 50%. The completion rate dropped to 4% for students who began their remedial work at the lowest levels (Nawrocki et al., 2009). The completion of a remedial course sequence (particularly one in mathematics) does boost academic success in equivalent college-level courses, and students who do so complete their program of study at the same rates as students who did not place into remedial courses (Bahr, 2008; Bailey et al., 2010; Johnson, 1996).

Students whose placement test scores put them near the dividing line between remedial and college-level course placement may suffer academically when they fall on the remedial side of that line. This effect has not been shown to be consistent. A 2010 study looked at the program completion rates for students who scored near the top of the remedial placement range on their college placement tests, and were placed into a remedial class. Those students had a lower level of program completion than students who tested into the college-level range on their placement tests (Boatman & Long, 2010).

Other studies which looked at academic success rates for students who placed near the cut score point for remedial or college-level course placement, and were advised to enroll in remedial courses but declined, found these students performed academically at the same rate as students who did take the remedial courses (Attewell et al., 2006; Jenkins et al., 2009).

For students who are prescribed a multi-course developmental education sequence, recent studies indicate few of them complete the entire sequence and then enroll in a college-level course. A study focused on California community colleges found that 81% of students who placed into an introductory developmental mathematics course never completed the entire course sequence (Bahr, 2008).

A 2010 study revealed that, of students who were placed into a multi-course developmental education mathematics course sequence, only 33% of the students finished the entire sequence within three years. Of the 33% who did complete the sequence, 20% successfully completed a college-level course during the timeframe of the study (Bailey et al., 2010).

When students maintain continuous enrollment during their transition from successful completion of a developmental education course sequence to their first college-level mathematics course, their likelihood of academic success is increased (Johnson, 1996). This finding was also supported by Diaz (2010), whose interview with Karr revealed that students who do not maintain continuous enrollment between remedial and college-level mathematics course–and instead have a gap of one or more semesters between enrollments–see academic success rates drop by 50%. Despite these findings, research has shown that the majority of students who complete a developmental mathematics course sequence wait one or more semesters before enrolling in college-level math courses (Nawrocki et al., 2009).

Academic Success of Developmental Education Students in Subsequent Credit – Bearing Courses

Although the question addressed by the previous studies is pertinent, what seems of more importance to colleges and universities is how well remediated students perform in college level math courses. The field of remedial and developmental education is built upon the foundational belief that all learners are capable of succeeding at the postsecondary level (Boylan, 1995). When implemented in a classroom, this belief should result in college-level academic performance from students who may have not been prepared for their postsecondary experiences (Bahr, 2007; Boylan, 2002).

The question of how well remediated mathematics students perform in subsequent college level math courses formed the basis of two major studies in the 1980s. A 1983 study of developmental education students enrolled at Walters State Community College found that 75% of students who enrolled in one or more remedial math courses successfully completed the entire developmental sequence. And of those students, 15% passed their first attempted college-level mathematics course with a grade of C or better (Hector, 1983). Another study from two years later compared the college-level mathematics success rates for two student cohorts at Ramapo College. The first group consisted of 130 students who placed out of remedial courses and enrolled directly into a college-level algebra course. The second group consisted of 75 students who enrolled in the college-level algebra course after successfully completing a developmental mathematics course sequence (Wepner, 1985). The results showed similar levels of academic success between the cohorts, with 81% of the remediated students successfully completing the college-level algebra course, compared to 80% of the non-remediated students (Wepner, 1985).

The truest test of remedial education programs may be to compare the academic performance of remedial graduates with those students who did not require remediation (Levine, 1990). Studies using this test model have shown that remediation works when students complete a prescribed remediation sequence, and then maintain continuous enrollment into college-level courses. In these circumstances, their academic output is comparable to those who placed directly into college-level courses (Wepner, 1985; Porter, 1988).

This section of the literature review outlined research focusing on traditional and historical measures, barriers, and facilitators of academic success for developmental education students. The concept of systematic research focusing on the issue of academic success is largely founded upon the work of Tinto, whose research beginning in the 1970s brought to light the importance of faculty/student interaction, and the quality of the academic and social support a student receives in their first year of college enrollment, as crucial to the formation of coping strategies that a student will use to carry them through their entire educational experience (Tinto 1987, 1993). This faculty/student interaction concept is central to the modular course format, which includes emporium-style courses. A number of research studies have shown that modular courses demonstrate higher levels of academic success, as compared to traditional course formats (Erickson, 2013; Hodara, 2011).

The evolution and growing popularity of college transfer in general, and reverse transfer in particular, has created a windfall for students who begin their academic careers at community colleges, for these institutions provide the remediation options often missing from other competing colleges (Townsend, 2001). Research shows that reverse transfer students, when compared to first-time community college students, demonstrate higher levels of academic success and persistence, along with a higher likelihood of completing a baccalaureate degree (Cohen & Brawer, 2008; Townsend, 2000). Research studies focusing on academic success rates are often intertwined with those also focusing on persistence, retention, and completion. Studies that have looked at all four of these factors reveal the importance of ensuring students are placed in the highest possible developmental course based on placement test scores, as well as ensuring students are successful in their first attempted developmental course, as this offers the quickest pace for remedial completion, and helps to minimize any stigma the students may associate with taking these types of courses (Bahr, 2007; Bailey, Jong, & Cho, 2010; Hadden, 2000).

There is a growing body of research that establishes a clear correlation between the length of time a student is enrolled in remedial classes, and their likelihood of academic success. Research looking at developmental course acceleration strategies shows a clear connection between the pace of course completion, and the likelihood of academic success and completion (Epper & Baker, 2009; Rotman, 2012). The issue of self-paced courses has also emerged in the research literature as a promising method of course completion acceleration via its use of mastery learning concepts, and allowing students to control the pace at which new course concepts are introduced (Cox, 1990; Roueche, 1983; Slavin & Karweit, 1985). Research has also shown that self-paced courses may be further improved by using mandatory support services, controlling the student/teacher classroom ratio, and implementing computer-assisted instructional technology within a lab setting (Epper & Baker, 2009).

Organizations such as Achieving the Dream, the Lumina foundation, and the Bill and Melinda Gates Foundation have invested in promising research focusing on academic success in the developmental education course setting. Their research findings highlighted modular curricula, classroom technology integration, intensive academic support, and active learning techniques as crucial to a student's academic success (Mayer et al., 2014; Quint, Jaggars, Byndloss, & Magazinnik, 2013; Rutschow, 2011). Studies seeking to track the overall academic success levels of developmental education students show inconclusive results, with a range of positive, negative, and neutral relationships (Bailey et al., 2010; Boylan & Bonham, 2011; Johnson, 1996; Nawrocki et al, 2009; Vandal et al., 2010). Key factors affecting success for these students include the initial level of developmental course placement, placement test scores, and semester-to-semester persistence (Attewell et al., 2006; Boatman & Long, 2010; Jenkins et al., 2009). For remediated students who complete a developmental course essence and enter into college-level courses, research reveals that they academically succeed at levels comparable to students who placed directly into college-level courses (Hector, 1983; Porter, 1988; Wepner, 1985).

The findings of this literature review section contribute to the study by showing the importance of accurate course placement, close faculty/student classroom interaction, self-paced course delivery via computer-assisted instruction, and accelerated course delivery formats as some of the keys to academic success for students enrolled in developmental mathematics courses. These concepts were reinforced by the research commissioned by external organizations seeking to support the work of community college remedial programs. These findings were further validated by additional research showing students who remediated in this type of environment performed as well or better in their college-level mathematics courses than those students not receiving any type of remediation.

Emporium Delivery Format and Developmental Education Mathematics Courses

With the advent of new technology options for course delivery, the emporium course format, utilizing computer-assisted instructional delivery, has taken center stage as one option for increasing academic success rates in developmental education mathematics courses. The power of technology as a tool for enhancing learning was identified beginning in the 1970s, as the technologies available at the time evolved to include more opportunities for individualized instruction based on user responses to assessments and other prompts (Cross, 1976).

There is a body of research that positions computer-assisted instructions as comparable to face-to-face instruction in terms of examined student outcomes, student attitudes, and overall student satisfaction (Lesh & Rampp, 2000; Perez & Foshay, 2002; Tucker, 2002). Nevertheless, high drop-out rates have been identified with classes that utilize a high degree of technology for instructional activities, including remedial mathematics courses that contain a computer- based instructional delivery component as part of classroom instruction (Bendickson, 2004; Kozeracki, 1999; Phipps & Merisotis, 1999). This dropout phenomenon presents an opportunity for future research.

Emporium Delivery Format and Impact on Academic Success, Persistence, Retention, and Completion of Developmental Mathematics Students

A series of initial studies from the mid-1980s onward sought to identify the specific impact on academic success, retention, and completion of new technologies and self-paced instruction, two features that would later be incorporated into the emporium model. A 1984 study compared a classroom using self-paced group instruction with a mastery learning model to a classroom utilizing the traditional lecture format. The self-paced, mastery learning group reported significantly higher academic success rates (Eckart, 1984). Robinson (1990) compared the academic achievement of developmental mathematics students taught in a self-paced lab using computer-assisted instruction with students enrolled in the same course using a traditional lecture format. Students enrolled in the self-paced lab exhibited significantly higher final grades sores. This same outcome was also observed for another study that compared academic achievement between developmental mathematics courses taught in a self-paced, computer-assisted-instruction format and those taught in a traditional lecture format (Toet, 1991). For these studies, alternative course delivery formats helped students to achieve higher levels of academic success. Opportunities exist to identify the specific elements of the alternative formats that had the most significant impact on these differences in academic performance.

More recent studies, supported by national organizations and educationally-focused foundations, have sought to investigate how the latest instructional technologies have made impacts on the pace of learning in remedial classrooms. The National Center for Academic Transformation (NCAT) first proposed the emporium model course redesign in 1999. Their innovative approach sought to simultaneously increase academic success rates while reducing both the time students spent in remedial courses and the amount of money institutions spent on such courses (Twigg, 2011). NCAT's course redesign approach involves a weaving of technology into all aspects of the course, as well as a redesign of the entire course (Twigg, 2011).

A notable program that used the NCAT-developed course redesign approach mentioned above is the Program in Course Redesign. This initiative, conducted from 1999-2003 by NCAT and funded by the Pew Charitable Trusts, focused on the use of technology as a means to both improve the quality of large-enrollment courses and reduce their cost (National Center for Academic Transformation, 2005). The 30 participating institutions were selected from a nationwide pool of applicants, and each received a grant of $200,000. Participating institutions included four- and two-year private and public colleges. The initiatives at each institution shared six key characteristics: a focus on whole course redesign (innovation must take place in all course sections and technology adoption technology must be woven through the entire course), inclusion of active learning and computer-assisted learning resources, assessment using mastery learning, on-demand assistance for students, and the use of alternative staff such as peer tutors and course assistants (Twigg, 2003). Results from the 30 participating institutions show 25 of them saw statistically significant increases in student learning, and 18 showed statistically significant improvements in retention, while program costs were reduced an average of 37% (Epper & Baker, 2009; National Center for Academic Transformation, 2005; Twigg, 2003).

NCAT's Program in Course Redesign initiative placed an emphasis on the emporium model. Defining features of the emporium model, as defined by NCAT, include: the replacement of the lecture environment with a learning resource center model that uses interactive software and on-demand personalized assistance; learning activities that are delivered and assessed using computer workstations loaded with instructional software, interactive tutorials, practice exercises, reference tools such as frequently asked questions, and online quizzes and tests; and a staffing model incorporating embedded classroom support in the form of teaching assistants and peer tutors, who are deployed in a manner where they respond directly to students' specific needs (National Center for Academic Transformation, 2012a).

The high-touch components of the emporium model–particularly, the on-demand personalized assistance, and classroom staff who respond directly to students' specific needs–align with Tinto's foundational academic success research mentioned earlier in this literature review, which emphasizes the quality and quantity of student/faculty interactions during a student's first semesters of study as highly predictive of the student's likelihood of academically succeeding and completing a prescribed program of study (Tinto, 1987, 2006).

Some states have also enacted their own research initiatives to look at ways of using technology in remedial classrooms as a way to improve academic success, persistence, and retention, while accelerating the pace of remedial course completion. Among the states who have taken this path is Tennessee. The Tennessee Board of Regents, as part of a three-year research initiative, conducted developmental education experiments as pilot programs at several community colleges in the state, as well as one four-year institution. Their goals with these efforts were to: accelerate completion rates for developmental mathematics courses; reduce the time students spent in the courses; and reduce institutional expenditures on these courses (Berryman & Short, 2010; Epper & Baker, 2009; Lucas & McCormick, 2007). Three Tennessee community colleges participating in this initiative were Cleveland State Community College, Jackson State Community College, and Northeast State Community College (which chose to focus on its developmental reading and English courses).

For the two colleges focusing on remedial math, the existing developmental mathematics courses were redesigned into modules which students could complete in as little as one week. A pre-test was used to identify into which module students would be placed**.** Students next worked with a representative to create an individualized learning contract that outlined the path to their identified educational goals. The courses consisted of one hour of instruction and two hours of computer lab time per week, using the emporium Model developed by NCAT. Students utilized computer software for all graded activities and also had access to online videos of class lectures. Faculty focused on spending one-on-one time with students while they were in the emporium labs, which had two or three faculty on hand at all times. This was facilitated by the use of computer-assisted instruction, which delivered interactive lectures and handled all assignment grading. Tutoring services were also accessed on-demand as needed by students. Because of reduced class sizes, the instructor load during the pilot was increased from 5 to 10 course sections (Berryman & Short, 2010).

Overall, these pilots showed that, by using the emporium model, it was possible to make significant increases in student success, while simultaneously reducing overall instructional cost per remediated student. The savings ranged from 19% to 51%, and took place concurrently with a statistically significant improvement in both final grades score and student retention from fall semester to fall semester (Berryman & Short, 2010). The pilots at both mathematics-focused institutions had a positive effect on course completion rates, with students who enrolled in one of the redesigned course sections twice as likely to complete the course with a grade of C or better as compared to completion rates prior to the redesign. This positive effect was also observed for subsequent academic performance in later developmental education courses taken by the students who participated in the pilot (Berryman & Short, 2010; National Center for Academic Transformation, 2012b).

At the completion of the pilot, the institutions chose to revise their college-level mathematics curriculum in order to deliver it using the emporium model as well (Berryman & Short, 2010). As of 2011, no public four-year institutions offer remedial courses in Tennessee; these courses are now only offered at public two-year colleges. This impending change provided the impetus for two-year schools to make modifications aimed at increasing the effectiveness of their remedial offerings (Berryman & Short, 2010).

Technology innovation has become expected and almost commonplace in modern society, and has–as predicted–become a driving force for continuous changes in the economic, educational, and political realms of our society (Marx, 2006). These changes have brought about new avenues of opportunities, as well as new sets of expectations, for today's typical community college student. The modern student often expects the same level of technology in their classroom experiences as they encounter in other parts of their life (Miller, Pope, & Steinmann, 2005).

The any time, any place, any pace aspect of modern course technology make it possible for students to better juggle personal, professional, and educational commitments. Faculty are able to combine diverse teaching methods with a broad portfolio of technology tools, such as learning management systems and synchronous communication activities to better serve students who possess a range of learning styles (Kinney & Robertson, 2003; Spradlin & Akerman, 2010).

A primary instructor concern when adopting instructional technology is the need to ensure students have the ability and comfort levels necessary to productively use any classroom or instructional technology (Boylan & Bonham, 2011). According to Boylan (2011), adult learners need to master mathematics concepts first before seeking to utilize technology as part of their learning experiences. One challenge of technology use in education is the rapid pace at which technology evolves, which requires instructors to continuously rethink their technologies strategies and adopt the latest technology updates (Charters, 2013). Research also shows that many instructors continue to be reluctant to incorporate the latest technological innovations into their teaching processes, continuing a trend that emerged when the first hand-held calculators appeared (Epper & Baker, 2009; Golfin et al., 2005; Thiel et al., 2008). This resistance to instructional technologies may stem from a review of research, which reveals a range of positive and negative educational outcomes coinciding with the use of classroom technology (Simms & Knowlton, 2008; Young, 2005). According to Epper and Baker (2009), the importance of researching and evaluating technology-driven innovations in developmental education mathematics programs has taken a back seat to the overall fast-paced implementation of these innovations.

A review of current literature reveals varying results as to the impact of computer-assisted instruction on student learning outcomes. A review of studies by Golfin et al. (2005), found a range of results when comparing computer-assisted instruction to traditional instruction, including higher levels of academic success, lower levels and academic success, and no significant effect. The 13 studies using computer-assisted learning which were reviewed as part of Hodara's (2011) literature meta-analysis revealed that eight of the 13 had research design and methodology issues that made their results suspect.

The expansive range of hardware and software technologies available may be one factor driving these mixed research results. The current portfolio of technologies includes Hawkes, MyMathLab, Plato, and ALEKS, among many others (Epper & Baker, 2009). Other factors may include how the technology is used in the classroom, how the technology is made available to students outside the classroom as they complete homework or work with tutors, and the level and quality of technology training made available to instructors (Lipika & Lieberman, 2013).

The newest research on computer-assisted instruction shows that this instructional method may show increased levels of student academic success. A review of research studies by Kinney and Robertson (2003) found that computer-assisted instruction achieves student success rates equal to that of traditional, lecture-based instruction. Jacobson (2006a) studied students enrolled in a pre-algebra class at a four-year university over a four-week period. The study found similar levels of academic achievement between those students enrolled in course sections using computer-assisted instruction and those enrolled in section with a traditional lecture format.

A report by Taylor (2008) analyzed academic achievement in intermediate algebra classes, and found that students enrolled in classes using ALEKS performed at the same level as students enrolled in the traditional classes, after controlling for age, gender, and ethnicity. Finally, a study by Spradlin and Ackerman (2010) analyzed academic success for students enrolled in an intermediate algebra class using CengageNow. The results revealed academic achievement for the CengageNow students was on par with students enrolled in traditional classes.

Seal (2008) looked at academic success rates for students enrolled in a college-level algebra course at a community college. The study compared success rates for a course taught using traditional lecture techniques, and one that implemented computer-assisted instruction. A review of student academic performance in remedial math courses, which made a computer–assisted instructional component available during class for the completion of homework activities, showed increased levels of student academic success and lower withdrawal rates (LaManque, 2009). It should be noted, however, that this same study revealed the students displayed lower levels of academic performance once they enrolled in college-level math classes.

Charters (2013) investigated course completion rates for developmental education mathematics courses held at a Hispanic-serving community college which were taught in either a traditional format or an emporium format incorporating computer-assisted instruction. Results showed students enrolled in the emporium classes experienced increased course completion rates. A similar study also looked at the effect of the emporium model and its use of computer-assisted instruction, on the academic success rates for students who completed a developmental mathematics algebra course and continued into college-level algebra. Results showed that students enrolled in the emporium versions of both the developmental and college-level algebra courses showed significant increases in academic success when compared to students who took the same courses in different formats (Vallade, 2013). A study examining the implementation of computer-assisted instruction in a remedial math course via the software package MathXL found both increased student success rates and a drop in course withdrawal rates (Buzzetto-More & Ukoha, 2009).

But this improvement in withdrawal rates was countered by Zavarella and Ignash (2009), who found a significant increase in withdrawal rates and a reduction in retention rates for students enrolled in remedial mathematics courses with a computer-assisted instruction component.

A review of the current literature finds evidence of additional scenarios where developmental education classes taught in a traditional format are found to have either the same or equal academic effect as opposed to those classes which implement a computer-assisted instruction component. In a 2006 study, Trenholm found equal levels of academic success for college students enrolled in a pre-algebra class that used MyMathLab as a computer-assisted instructional component, and students who enrolled in sections of the same course that were taught without MyMathLab in both seated and online versions. A 10-year study looking at developmental education courses taught at a Texas college found roughly equivalent academic performance between students enrolled in classes with a computer-assisted component, and students who enrolled in the same classes taught in a traditional lecture format (Zhu & Polianskaia, 2007).

The claim that computer-assisted instruction has a positive effect on both academic learning and student attitudes toward learning appears in a number of research studies (Adams, 2003; Buzzetto-More & Ukoha, 2009; Bargagliotti, Botelho, Gleason, Haddock, & Windsor, 2012; Jacobson, 2006a; Kulik & Kulik, 1991; LaManque, 2009). Some studies have revealed that computer-assisted instruction can become the preferred method of instruction for students, as well as help decrease their anxiety toward enrolling in mathematics courses (Buzzetto-More & Ukoha, 2009; LaManque, 2009; Taylor, 2008), but a few studies have also shown negative student perceptions of computer-assisted instruction (Thiel et al., 2008; Stewart, 2012).

The FastStart program implemented by the Community College of Denver–which combined mastery learning and computer assisted instruction to help students quickly complete development mathematics courses - is one of the innovative programs identified in recent literature employing a technology component (Epper & Baker, 2009). Another initiative, the Carnegie Foundation’s Statway and Quantway program, showed promise for improving the persistence, retention, and academic success of students seeking to move quickly through developmental mathematics course sequences (Hern, 2010). Starting in September 2009, the Statway and Quantway initiatives were developed by the Carnegie Foundation, along with a partnership of 27 community colleges and 3 universities. The initiative had a goal of reconceiving the developmental mathematics pathways in community colleges using two distinct curricula; one focused on statistics, and one focused on quantitative reasoning. The Statway and Quantway curricula are delivered in distinct modules that may be completed sequentially in one semester (for Quantway) or one academic year (for Statway). The hope was to double the number of students prepared for further academic study, while demonstrating to students the usefulness of mathematical knowledge in their everyday lives. The initiative included some elements of the emporium model, among them: one-on-one collaboration and instruction between the student and teacher, self-paced instruction, and the use of technology to make the course material and activities available both inside and outside of the classroom (Merseth, 2011; Van Campen, Sowers, & Strother, 2013). The latest results for 2012-2013 show that 52% of Statway students completed the one-year pathway course with a grade of C or higher, an increase over the 2011-2012 results of 49%. Quantway results for 2012-2013 show 52% of enrollees completed the one-semester pathway, as compared to 56% during 2011-2012 (Van Campen, Sowers, & Strother, 2013).

The broad range of research results documented in the preceding paragraphs of this literature review with respect to the impact of computer-assisted instruction on academic success demonstrates that the challenges of developmental education learners may not be resolved with one broad solution (Schwartz & Jenkins, 2007). Instead, success strategies must recognize that developmental education students come to class with a wide range of experiences, ability levels, and learning styles. As such, they will need access to a wide range of different instructional approaches (McMillan et al., 1997). This “cafeteria of learning” approach will place the use of computer-assisted instruction in the proper context of just one of many course formats and instructional options available to accommodate the needs of diverse learners (Kinney & Robertson, 2003; LaManque, 2009; Spradlin & Ackerman, 2010; Taylor, 2008; Zavarella & Ignash, 2009; Zhu & Polianskaia, 2007). This view is supported by studies showing students who were able to choose their developmental education mathematics course delivery format exhibited higher levels of course satisfaction and completion (Kinney et al., 2004; Zavarella & Ignash, 2009).

After conducting a literature review that looked at various remedial program improvement initiatives, Epper and Baker (2009) determined that many community colleges in the United States are currently implementing a broad portfolio of innovative developmental education programs that include a range of best practices and techniques such as the use of technology, student engagement, master learning, and active learning. The work of Epper and Baker is echoed by Vandal et al. (2010) and Boylan and Bonham (2011), who have also found that student achievement in developmental education courses is increased through the use of interactive, computer-assisted, and modularized instruction that incorporates mastery learning techniques.

The focus of this literature review section was research looking at the effect of computer-assisted instruction, and the emporium course format in particular, on the persistence, retention, success, and completion rates for developmental mathematics courses. Research into classroom technology grew from the 1970s onward, as personal computers and other modes of technology-based instructional delivery began to be deployed in classrooms (Cross, 1976).

Computer-assisted instruction was initially shown to create student learning outcomes comparable to traditional lecture environments that used face-to-face instruction. The self-pace instruction and mastery learning components of the new instructional technologies were identified as key benefits contributing to better academic success rates (Lesh & Rampp, 2000; Perez & Foshay, 2002; Tucker, 2002). But other, equally rigorous studies countered these findings by uncovering increases in drop-out rates as compared to traditional course formats (Bendickson, 2004; Kozeracki, 1999; Phipps & Merisotis, 1999). As technology advanced, and educators developed a more nuanced understanding of its benefits in the classroom, a model for computer-assisted instruction, called the emporium model, began to emerge. The key components of the emporium format, including the self-paced, interactive instruction delivered via software, mastery learning approach, and individualized student assistance (National Center for Academic Transformation, 2012a).

As was seen with the first generation of instructional technology, research looking at the implementation of emporium model components in the classroom revealed a range of positive and negative outcomes. Research initiated by NCAT, the Community College of Denver, the Carnegie Foundation, and states such as Tennessee showed emporium to be an effect delivery model for developmental mathematics courses, resulting in increases in student learning and reduced instructional costs versus other delivery methods (Berryman & Short, 2010; Epper & Baker, 2009; Hern, 2010; Lucas & McCormick, 2007; National Center for Academic Transformation, 2005; Twigg, 2003). But other studies showed inconclusive results for the emporium model in the areas of academic success and persistence (Hodara, 2011; Simms & Knowlton, 2008; Young, 2005; Zavarella & Ignash, 2009).

Additional studies also showed the important role that faculty perceptions and on-going professional developmental play in ensuring that classroom technology is used appropriately and to its best purpose. These studies implied that the pace with which technology is being introduced into the classroom may have outstripped educators' understanding of how best to incorporate the technology into learning activities and the curriculum (Boylan & Bonham, 2011; Charters, 2013). Further emporium-focused research has shown that this model fits the expectations of today's community college students, who arrives in class with a high level of comfort with technology. These students seek technology–intensive models of course delivery, as well as flexibility in course scheduling (Miller, Pope, & Steinmann, 2005).

The findings of this literature review section contribute to the study by revealing the opportunities to investigate computer-assisted instruction and the emporium course delivery format, with a specific focus on how they may impact the persistence, retention, success, and completion rates for students enrolled in developmental education mathematics courses.

Summary

There is a large and growing body of literature focusing on computer-assisted instruction and its effect on student achievement. Since technology began to appear in classrooms, researchers have sought to effectively evaluate whether it is significantly impacting student achievement (Haertel & Means, 2003).

When taken in its totality, the body of research identified in this literature review reveals that, while computer-assisted instruction and the emporium format classes have been shown to demonstrate increased success, retention, persistence, and completion rates, this remedial course delivery format may benefit from further investigation. This is due to the fact that the pace by which computer-assisted technology is being introduced into developmental mathematics classrooms has far outstripped attempts at systematic and robust evaluation of these changes, using sound research methodology, that is aimed at pinpointing improvements in success, persistence, retention, and completion rates. The literature and research studies reviewed in this chapter support the contention that current research initiatives in this field may be seen as broad, somewhat diffused, and variable. Additional studies may serve to help create a clear trend and conclusive evidence as to what definitively works – and does not work - with select student populations.

This research study attempted to address this identified research gap by investigating the emporium course delivery format and the impact such a course format may have on the academic success, persistence, retention, and completion rates of community college students enrolled in developmental education mathematics courses who then proceed into college-level courses. By contributing to the growing body of research in this area, this study helped to ensure that the mission and benefits of remedial mathematics education in a community college setting may remain viable well into the 21st century.

CHAPTER 3: METHODOLOGY

This study examined whether an emporium course delivery format predicted the academic success, retention, persistence, and completion of students enrolled in developmental mathematics courses. This chapter describes the context, sample, design, variables, instruments, procedures, and planned data analysis.

Research Questions

The research questions for this study are as follows:

- **Q1:** How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict developmental mathematics course completion?
- **Q2:** How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict first-to-second-semester developmental mathematics course persistence?
- **Q3:** How well does developmental mathematics course format predict retention?
- **Q4:** How well does developmental mathematics course format predict gateway curriculum mathematics course completion?
- **Q5:** How well does developmental mathematics course format predict the success of students as measured by transfer, completion of a curriculum terminal degree, diploma or certificate within 150% of normal time, or continued enrollment?

Context

The setting for this study was a two-year, public community college in North Carolina. The college is classified as an Associate's college, public suburban-serving, multicampus institution by the Carnegie Classification of Institutions of Higher Education (2014), and offers academic transfer and career and technical education programs, as well as workforce development and continuing education opportunities. This college adheres to the open door admission policy that allows students from all socio-economic strata an equal opportunity to begin the path to a postsecondary education. Many of the students applying to this institution enter the college unprepared for college level mathematics (National Center for Academic Transformation, 2012). Developmental mathematics courses are provided to give students an opportunity to improve their math skills and become successful college-level mathematics students.

Integrated Postsecondary Education Data System (IPEDS) data for Fall 2013 reported a total enrollment for the college of 13,656 students. Approximately 57% of the students were female and 43% were male. The ethnicity of the population was 43% Black or African-American, 41% White, 6% Hispanic, 4% Asian, and 1% American Indian/Alaskan. Fifty-two percent were 24 years of age or younger, and 48% were 25 years of age or older. Fifty percent of the students took a full-time course load equal to 12 or more semester hours (U.S. Department of Education, 2014).

In creating the redesigned, emporium-based versions of the existing developmental mathematics courses, the college had three goals: (a) increase the number of developmental mathematics course sequence completers; (b) identify and fill in knowledge gaps stemming from concepts learned in previous courses; and, (c) increase the overall completion pace for each developmental mathematics course (National Center for Academic Transformation, 2012). The college redeveloped the curriculum for its three existing developmental mathematics courses using the emporium model, resulting in 13 discrete course modules.

Sample

The sampling frame of this study included 3,792 spring 2011 students who were enrolled in different sections of the same remedial math courses, offered in a traditional lecture-based format (3,573 students) or an emporium format (219 students). Spring 2011 data were used for this study because that was the semester selected by the institution under study for implementation of the previously described pilot. Although the original data file contained 219 emporium format students, it was necessary to delete 31 students who earned grades of “W” or “I” for the spring 2011 developmental mathematics course, leaving a net of 188 students. Once the data for this study was received, the researcher and methodologist utilized demographics and other variables to match an equivalent number of students who enrolled in the emporium format and traditional lecture-based format sections of Essential Mathematics (MAT 060), Introductory Algebra (MAT 070), or Intermediate Algebra (MAT 080) for the spring 2011 semester. The matching process consisted of pairing an emporium-format student with a traditional-format student via the following characteristics:

- Matching based on the specific developmental mathematics course taken in spring 2011 (MAT 060, MAT 070, or MAT 080).
- Matching based on whether the student did or did not enroll in a subsequent gateway curriculum mathematics course.

- Matching based on financial aid status.
- Matching based on gender.
- Matching based on ethnicity.

At the completion of this process, the sample of 376 students consisted of 188 students in emporium-format courses, and 188 students in traditional-format courses. This number exceeds the required minimum sample size for the given population; N=4000, s=351 (Krejcie & Morgan, 1970). All class sections were taught by a combination of full-time and part-time adjunct faculty.

The institution's core developmental mathematics course sequence in spring 2011 consisted of MAT 060, MAT 070, and MAT 080. Each course served as a prerequisite for the other. Students were initially placed into one of these three courses based on their placement test scores. Students were required to successfully complete their assigned remedial mathematics course sequence before enrolling in the gateway college-level mathematics course specific to their chosen program of study. While MAT 050 (Basic Math Skills) was listed in the institution's official 2010-2011 catalog, any sections of that course which may have been offered in spring 2011 were not part of this study.

Students self-enrolled in available courses based on personal preferences and their performance on the college-administered mathematics placement examination. Students selected a course section that would meet their needs, and completed the registration process either on their own or with the assistance of college personnel. None were told that courses utilized two different teaching methodologies. Approximately 25% of all developmental mathematics course sections were taught by full-time faculty, with the remainder taught by adjunct faculty. All class sections used a departmental syllabus, curriculum and textbook. All courses adhered to the same curriculum outlined. The overall pass rate for all courses was 48%.

The emporium group included students who enrolled in the emporium sections of three selected classes. These students received emporium model instruction in a computer lab. The comparison group included students who enrolled in the traditional sections of each class. The majority of students in both groups took classes on the same college campus.

Key demographic criteria for the students enrolled in these courses, including age, gender, ethnicity, and financial aid status, were described using descriptive statistics. Instructors were described using the demographic criteria of employment status and length of employment at the institution.

Self-selection by students into treatment and comparison groups has become an acceptable methodology in educational research studies, assuming the two groups do not differ significantly, and procedures are used to assess homogeneity and control for confounding effects. This participant procedure has been used in other studies looking at the effectiveness of computer-assisted instruction in mathematics courses (Wardlaw, 1997).

Research Design

This study used a non-experimental, *ex post facto*, regression design. In such a design, the researcher is a passive agent, who focuses on observing, measuring, and describing a situation as it exists (Huck, 2012). In this case, self-selected registration into a specific course section, data collection, and course completion have already occurred. Non-experimental research may be distinguished by two distinct types of studies.

Descriptive studies are those where the researcher serves as a passive agent who observes, measures or describes phenomena as they occur or exist. Correlational studies seek to describe the relationship between variables. Each of these types of studies is considered non-experimental because there is no manipulation of the independent variable. Because there is no direct manipulation of the independent variable by the researcher, non-experimental research is not able to establish causality (Garson, 2012; Huck, 2012).

Variables

Data for this study came from archival records collected during the spring 2011 semester and matched with outcome data from subsequent semesters. All of the student and academic data that was analyzed pre-existed in the data warehouse at the North Carolina community college under study, and was obtained through the college's Office of Institutional Research and Planning. A compilation of the variables used in this study is shown in Tables 3 and 4. Table 3 displays the predictor variables, level of measurement, and definition.

Table 3: Predictor Variables

Name	Level of Measurement	Definition/Value
Student demographics - Age	Ratio (discrete)	Values: Student age as of spring 2011
Student demographics - Gender	Categorical (nominal dichotomous)	Values: male, female
Student demographics - Ethnicity	Categorical (nominal)	Values: American Indian or Alaska Native; Asian; Black or African

		American; Native Hawaiian or Other Pacific Islander; White
Student - demographics Financial aid status	Categorical (dichotomous)	Values: Pell Grant recipient, non-Pell Grant recipient
Student - Enrolled course	Categorical (ordinal)	Values: Essential Mathematics (MAT 060); Introductory Algebra (MAT 070); or Intermediate Algebra (MAT 080)
Course format	Categorical (dichotomous)	Values: Emporium format, traditional format.
Course instructor–Employment status	Categorical (dichotomous)	Values: Part-time, full-time
Course instructor–Length of employment	Ratio (discrete)	Values: Instructor's length of employment at research location as of spring 2011

Table 4 displays the criterion variables, level of measurement, and definition. The definitions utilize the National Center for Education Statistics' IPEDS database and the AACC's Voluntary Framework for Accountability (AACC VFA).

Table 4: Criterion Variables

Name	Level of Measurement	Description/Value
Developmental mathematics course – Completion	Categorical (ordinal)	Value: A, B, C, D, F, Pass, or Repeat on first developmental math course attempt **
Gateway curriculum mathematics	Categorical (ordinal)	Value: A, B, C, D, or F on first gateway curriculum mathematics course attempt.

course–Completion		
Retention	Categorical (dichotomous)	Defined as a student who maintained continuous enrollment at the institution from fall semester to fall semester. Values: retained, not retained ****
Persistence	Categorical (dichotomous)	Defined as a student who maintained continuous enrollment at the institution from the first semester to the next. Values: persisted, did not persist
Student success-College transfer	Categorical (dichotomous)	Defined as a student who has successfully transferred to a 2- or 4-year institution with 150% of normal time. Values: yes, no ***
Student success–Completion	Categorical (dichotomous)	Defined as a student who completed a curriculum terminal degree, diploma or certificate within 150% of normal time. Values: yes, no ***
Student success–Continued enrollment	Categorical (dichotomous)	Defined as a student whose enrollment persisted beyond the 150% of normal time window, and did not transfer to a 2- or 4-year institution, or complete a curriculum terminal degree, diploma or certificate.

*** Aligns with AACC VFA definition of student success.*
**** Aligns with IPEDS definition of completion.*
***** Aligns with IPEDS definition of retention.*

In order to run the logistic regressions, it was necessary to create some dummy coded variables for the analysis. Table 5 below shows the applicable variables and their corresponding dummy codes.

Table 5: Dummy Coded Variables

Variable	Dummy Coded Variables	Level	Value
Ethnicity			
	Ethnicity - African American	0, 1	No, Yes
	Ethnicity - Caucasian	0, 1	No, Yes
	Ethnicity - Other	0, 1	No, Yes
Transfer			
Completion			No if student transferred after 12/31/2013; completed after 12/31/2013; or did not transfer or graduate, and did not continue enrollment after 12/31/2013
Continued Enrollment			
	Success	0,1	Yes if student transferred prior to 12/31/2013; completed prior to 12/31/2013; did not transfer or graduate, but did continue enrollment after 12/31/2013

Interventions

Emporium format. The emporium model, as espoused by the National Center for Academic Transformation, is defined by its use of an active learning environment, in contrast to the traditional lecture model (Carey, 2009; Twigg, 2005). The model replaces the traditional, lecture-based classroom with a learning environment that includes technology workstations containing computer-assisted instructional software. These workstations facilitate students interacting with the software to complete math problems. The software guides the students through the problem-solving process with features such as videos, interactive tutorials, online practice problems, quizzes, and tests. These engaging features also address the range of student learning styles. Supplementing the workstation experience are instructors and facilitators who are available to work one-on-one with students. Students are also allowed to work in groups as appropriate. All of these resources allow students to receive immediate feedback as they work through math problems at their own pace (Twigg, 2005).

The mastery learning approach is another defining feature of the emporium model. The computer-assisted instruction component allows students to access course content at any time, but students are required to work in the emporium lab a minimum number of hours per week. With this structure, student progress may be monitored and interventions made at any point in the process as determined by the instructor. Once all instructional assignments are completed, the student may complete quizzes or tests as appropriate to assess content mastery before proceeding to the next instructional module. This environment, which includes regular practice, numerous formative assessments, and instant feedback, helps students to progress to the next course at a faster rate as compared to traditional methods (Twigg, 2003).

Each course module was constructed around a computer-assisted instructional format using MyMathLab. According to the developer of MyMathLab, Pearson Education, the software package includes PowerPoint presentations, lesson videos, audio clips, displays integrated graphs and diagrams, animated illustrations, and other multimedia learning aids (2014). For instructors, the MyMathLab system provides features for creating and managing homework, automatic grading via a built-in gradebook, and feedback tools for tracking the academic performance of individual students (Pearson Education, 2014).

Students were required to interact with the software five hours per week, with three of those hours taking place in a computer lab that had instructors and other facilitators present. Students who enrolled into one of the modules began their instructional experience with a pre-test. From there, they moved through the course as their skill development allowed, accessing the instructor and support resources as needed. Once the student completed the instructional activities and felt they were ready, they then took a post-test. A passing rate on the post-test allowed them to move onto the next module. In order to facilitate high levels of success and less test anxiety, students were allowed re-testing options for the post-test. In addition, they were allowed access to the MyMathLab software outside of the computer lab (National Center for Academic Transformation, 2012).

Traditional format. These courses utilized a traditional developmental mathematics course textbook which provided an explanation of math concepts, along with sample exercises. Instructors used classroom resources and visual aids to explain and describe mathematics concepts. The primary classroom resources accessed by students in this environment were paper, pencil, and textbook. Students were allowed to use electronic devices for notetaking. In the traditional course delivery model, the teacher used a writing board and verbal descriptions to explain course concept. During this process, students would take notes as needed. Once the concept lecture was completed, students would work on sample activities reinforcing the concepts just described. At the end of the class session, students would be assigned homework activities for completion on their own. Pre- and post-test modules were used within each chapter to monitor student progress.

Procedure

The students followed a course sequence that began with their placement into one of three developmental education mathematics courses (Essential Mathematics, Introductory Algebra, or Intermediate Algebra) and ended with the completion of one or more gateway college-level mathematics courses. The college-level courses consisted of Survey of Mathematics, Mathematical Concepts, Statistics, and Pre-calculus Algebra.

All IRB approvals were obtained prior to the beginning of the research. In accordance with the Family Educational Rights and Privacy Act, all student data were de-identified using a standard coding process. Each student record was assigned a unique identifying number. The researcher did not have access to student names, institutional identification numbers, or social security numbers. Archival data was collected from official college records of the study institution, providing an expedient and effective way to address the research questions. The use of archival data minimized any risks to human subjects, and all informed consent procedures were followed in accordance with the IRB policies of UNC Charlotte and the institution under study.

After completing IRB applications and approval processes at all relevant institutions, the coded, archival, de-identified student data were obtained via secure flash drive, as provided by the Office of Institutional Research and Planning at the institution being studied.

Data Analysis

Descriptive and inferential statistical procedures were used to analyze the data using the Statistical Package for the Social Sciences (SPSS), version 23.0 (UNC Charlotte, n.d.). Due to the lack of random assignment, evidence of group equivalence is needed in order to make inferences from this study to other community college setting and students (Dimsdale & Kutner, 2004). The first step in conducting an analysis of the data was to utilize descriptive statistics to describe the participants in the developmental math courses. Descriptive statistics helped to organize and summarize the data and create a frequency distribution of the variables. The mean, standard deviation, variances, and minimum and maximum values were calculated for the two groups under study on the variables of age, gender, ethnicity, and financial aid eligibility. Then, a chi-square test of homogeneity was used to analyze demographic differences in the two groups and ensure that they consisted of similar distributions in terms of the following independent, categorical variables: age, gender, ethnicity, and financial aid eligibility.

The research questions were answered by the use of logistic regression, which is a frequently used statistical procedure in the field of education for predicting retention and student success (Alexander, 2013; Echenique, 2007; Moore, 2014). Logistic regression is useful in non-experimental studies because it facilitates the prediction of discrete variables by a mix of continuous and discrete predictors (Huck, 2012). The logistic regression statistical model explains the relationship between two or more predictor variables and one or more dichotomous dependent variables (Garson, 2012; Tabachnick & Fidell, 2013). Logistic regression allows the researcher to predict the binary outcome of the dependent variable based on the predictor variables. Logistic regression analysis usually includes a test of significance. Odds testing is considered to be the most critical test of significance that a researcher employing logistic regression may perform (Garson, 2012; Huck, 2012).

The Hosmer-Lemeshow test was used to evaluate the logistic regression model for goodness-of-fit. In comparison to other goodness-of-fit procedures, the Hosmer-Lemeshow test is considered to be a more robust model, particularly in situations of relatively small sample sizes (Garson, 2012).

Logistic regression analysis is predicated upon a number of assumptions. The first assumption is that the dependent variables are dichotomous. Next, logistic regression assumes that the independent (predictor) variables do not need to be interval or ratio, nor must their levels of measurement be linearly related or of equal variances within the groups being studied. The third assumption is the existence of a large sample size. The goal is to have a sample size necessary to achieve the required acceptable level of statistical power. Fourth, logistic regression assumes no linear relationship between the dependent and independent variables. Finally, logistic regression assumes mutual exclusivity between groups being studied. This potential lack of independence of observations may lead to multicollinearity (Huck, 2012; Pampel, 2000).

The logistic regression analysis for each research question focused on identifying a statistically significant difference between the two groups studied by interpreting generated p-values of the coefficients. Following is a recap of the research questions, along with a description of the statistical procedures used to answer each research question.

- **Q1:** How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict developmental mathematics course completion? For the first research question, logistic regression analysis was used to determine if a model containing the predictor variables of student demographics (See Table 3), course format, course instructor employment status, and course instructor length of employment could predict the criterion variable developmental math course completion. The Wald test was performed to see if the odds ratio for a specific independent variable were statistically significant.
- **Q2:** How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict first-to-second-semester developmental mathematics course persistence? For the second research question, logistic regression analysis was used to determine if a model containing the same predictor variables of student demographics (See Table 3), course format, course instructor employment status, and course instructor length of employment variables could predict the criterion variable of first-to-second-semester developmental math course persistence. The Wald test was performed for this question as well, in order to see if the odds ratio for a specific independent variable were statistically significant.
- **Q3:** How well does developmental mathematics course format predict retention? For the third research question, logistic regression analysis was used to determine if a model containing developmental mathematics course format could predict retention.

- **Q4:** How well does developmental mathematics course format predict gateway curriculum mathematics course completion? For the fourth research question, logistic regression analysis was used to determine if a model containing developmental mathematics course format could predict gateway curriculum math course completion.
- **Q5:** How well does developmental mathematics course format predict the success of students as measured by transfer, completion of a curriculum terminal degree, diploma or certificate within 150% of normal time, or continued enrollment? For the fifth research question, logistic regression analysis was used to determine if a model containing developmental mathematics course format could predict student success–as measured by transfer, completion of a curriculum terminal degree, diploma or certificate within 150% of normal time, or continued enrollment.

Summary

This study sought to address the problem of understanding to what extent an emporium course delivery model impacted the amount of time community college student spend in remedial mathematics course, as well as whether the emporium model affected academic success, retention, college transfer, and completion for remedial mathematics students.

A non-experimental research design was used to address this research problem, due to the *ex post facto* nature of the study and the inability to ensure study fidelity. Student data was collected from official college records in a de-identified and coded state. A series of descriptive and inferential statistical procedures were then be performed. Logistic regression was used as the inferential statistical procedure. Measures were implemented to identify and control for the validity and reliability of the data. The conclusions drawn from this study serve as statistically valid results, due to the alignment of the research design and methodology with the research problems and questions (Huck, 2012).

CHAPTER 4: ANALYSIS OF DATA

Introduction

The purpose of this research study was to look at the delivery of developmental mathematics instruction in an accelerated emporium model learning environment, and how it may predict academic success, persistence, retention, and completion for students enrolled in developmental education math courses. The Participant Summary section of this chapter uses descriptive statistics to summarize the demographic and academic characteristics of students who are included in this analysis. Data are arrayed in tables using frequencies and percentages. The Procedure Summary and Results provides the results for each of the five research questions. All of the logistic regression analyses were conducted using SPSS.

Participant Summary

A descriptive analysis was conducted on the selected demographic variables for the student population under study. Analysis revealed that the mean age of the population was 36.8, with 49.2% of all students falling into the age group of 22 - 34. Females constituted 64.4% of the population, with males at 35.6%. The majority ethnicity was African American at 55.1%, followed by Caucasian at 35.9%. A review of financial aid status for students showed that 64.4% received Federal Pell Grants. Results are summarized in Table 6.

Table 6: Demographic Variables for Student Participants

Variable	F	%
Age Group		
22 to 34	185	49.2
35 to 44	109	29
45 to 54	64	17
55 to 64	17	4.5
65 and Over	1	.3
Total	376	100%
Mean	36.8	
Standard Deviation	9.30	
Gender		
Female	242	64.4
Male	134	35.6
Ethnicity		
African American	207	55.1
Caucasian	135	35.9
Hispanic	7	1.9
Asian	9	2.4
American Indian/Alaskan Native	4	1.1
Two or more races	1	.3
Unknown	13	3.5
Financial Aid Status		
Pell Grant Recipient	242	64.4
Non-Pell Grant Recipient	134	35.6

A review of the demographic variables for the instructors assigned to each developmental mathematics course under study shows that 71.5% of the classes were taught by full-time instructors, while 28.5% were taught by part-time instructors. Of these instructors, 44.2% had five or less years of teaching experience at the institution under study, while 42.6% had 6 - 10 years. Results are summarized in Table 7.

Table 7: Demographic Variables for Developmental Mathematics Course Instructors by Course Assignment

Variable	F	%
Employment Status		
Part-time	107	28.5
Full-time	269	71.5
Length of Employment		
0-5 years	166	44.2
6-10 years	160	42.6
10-20 years	37	9.9
More than 20 years	13	3.5
Mean	3.22	
Standard Deviation	5.97	

The academic variables under review in this study included course grades for the specific developmental mathematics course taken in spring 2011 (either MAT 060, MAT 070, or MAT 080), as well as the subsequent gateway mathematics course taken upon the completion of a prescribed developmental mathematics course sequence. Most of the students were enrolled in MAT 070 for the spring 2011 semester (54.5%), followed by MAT 060 at 23.9%, and MAT 080 at 21.5%. Analysis revealed that a grade of A accounted for 39.9% of developmental mathematics course grades, followed by a grade of B at 28.2%, with a grade of F following next at 23.9%. For the 151 students who went on to enroll in a gateway mathematics course, 12.2% enrolled in MAT 140, followed by MAT 161 at 10.1%, and MAT 115 at 8.2%. Of those students, 23.7% earned an A, followed by a grade of B at 6.6%, and a grade of C at 4.8%. Results are summarized in Table 8.

Table 8: Academic Variables for Student Participants

Variable	F	%
Developmental Mathematics Enrolled Course		
MAT 060	90	23.9
MAT 070	205	54.5
MAT 080	81	21.5
Developmental Mathematics Course Grade		
A	150	39.9
B	106	28.2
C	29	7.7
D	1	.3
F	90	23.9
Total	376	
Mean	2.60	
Standard Deviation	1.58	
Gateway Mathematics Enrolled Course		
MAT 101	1	.3
MAT 110	18	4.8
MAT 115	31	8.2
MAT 121	2	.5
MAT 140	46	12.2
MAT 143	3	.8
MAT 151	2	.5
MAT 161	38	10.1
MAT 171	10	2.7
Gateway Mathematics Course Grade		
A	89	23.7
B	25	6.6
C	18	4.8
D	6	1.6
F	13	3.5
Total	151	
Mean	3.31	
Standard Deviation	1.24	

Procedure Summary and Results

After reviewing the descriptive statistics for the data, a series of binary logistic and multinomial logistic regressions were performed using SPSS version 23.0. The logistic regression analyses were conducted to identify any influence the predictor variables had on the criterion variables. Binary logistic regressions were conducted because the criterion variables investigated in each research question had two levels. The Forward: Wald method was used as the test of significance for each of the coefficients in the logistic regression models. This method begins with no variables in the model and adds them one at a time, beginning with the variable estimated to make the biggest contribution to the model. Only the variables that are significant remain in the model. Variables determined to not be significant are removed using the Wald statistic (Garson, 2012).

Research question #1 asked how well course format, student demographics, course instructor employment status, and course instructor length of employment predict developmental mathematics course completion. To answer the question, a forward stepwise logistic regression using the Wald statistic as criteria for removal was run using SPSS version 23.0 with one criterion variable (developmental mathematics course completion) and nine predictor variables: age, gender, ethnicity (as three dummy coded variables), financial aid status, instructor employment status, instructor length of employment, and developmental mathematics course format. Course format and financial aid status were significant contributors to predicting mathematics course completion ($\chi^2 = 25.81$, df =2, $p < .01$).

The Nagelkerke R^2 indicates that this two variable model accounts for 9.9% of the variance. The Hosmer and Lemeshow Goodness of Fit Test indicates the two variable model is a good fit ($\chi^2 = 4.08$, df=2, p=.130). There is not a statistical difference between the observed and predicted number of course completion events. This indicates that while this is a statistically significant model, it accounts for less than 10% of the variance of developmental mathematics course completion. The remaining variance is accounted for by something other than age, gender, ethnicity, instructor employment status, or instructor length of employment. Table 9 displays the regression statistics for this model. The logistic equation for this model is:

Developmental mathematics course completion = $.215 + .936_{\text{course format}} + .890_{\text{financial aid status}}$

The odds of completing the developmental mathematics course are 2.6 times greater if the delivery is traditional and 2.4 times greater if financial aid status is Pell Grant recipient. The contingency tables displayed in Tables 10 and 11 illustrate percent course completion within course format and financial aid status. Eighty-four percent of traditional students and 68.1% of emporium students completed the developmental mathematics course. Eighty-one percent of Pell Grant receiving and 65.7% of non-Pell Grant receiving students completed the developmental mathematics course.

Table 9: Logistic Regression Table - Research Question #1

Variables	B	SE	OR	Wald	95% CI
Constant	.215	.216	1.240	.993	
Financial Aid Status	.890	.252	2.435	12.430	1.485 - 3.994
Course Format	.936	.258	2.550	13.144	1.537 - 4.229

Table 10: Percent Developmental Mathematics Course Completion and Course Format

Course Format	Developmental Mathematics Course Completion	
	Not Complete	Complete
Emporium	31.9%	68.1%
Traditional	16.0%	84.0%

Table 11: Percent Developmental Mathematics Course Completion and Financial Aid Status

Financial Aid Status	Developmental Mathematics Course Completion	
	Not Complete	Complete
Pell Grant Recipient	18.2%	81.8%
Non-Pell Grant Recipient	34.3%	65.7%

Research question #2 asked how well course format, student demographics, course instructor employment status, and course instructor length of employment predict first-to-second-semester developmental mathematics course persistence. To answer the question, a forward stepwise logistic regression using the Wald statistic as criteria for removal was run using SPSS version 23.0 with one criterion variable (Fall 2011 developmental mathematics course persistence) and nine predictor variables: age, gender, ethnicity (as three dummy coded variables), financial aid status, instructor employment status, instructor length of employment, and developmental mathematics course format. The regression focused only on Fall 2011 persistence because that was the next sequential semester to take place after the intervention under study, which occurred in the spring 2011 semester. Age and financial aid status were significant contributors to predicting Fall 2011 developmental mathematics course persistence (χ^2 = 59.78, df=2, p <.00).

The Nagelkerke R^2 indicates that this two variable model accounts for 21.1% of the variance. The Hosmer and Lemeshow Goodness of Fit Test indicates the two variable model is a good fit (χ^2 = 9.62, df=8, p=.292). There is not a statistical difference between the observed and predicted number of fall 2011 persistence events. This model accounts for 21% of the variance of fall 2011 developmental mathematics course persistence. The remaining variance is accounted for by something other than gender, ethnicity, course format, instructor employment status, or instructor length of employment. Table 12 displays the regression statistics for this model. The logistic equation for this model is: Fall 2011 developmental mathematics course persistence = 1.189 - $.034_{\text{age}}$ + $1.79_{\text{financial aid status}}$

The odds of persisting in a Fall 2011 developmental mathematics course are 5.98 greater if the student is a Pell Grant recipient, and only .97% as likely to persist for each one-year age increase. The contingency table displayed in Table 13 illustrates percent Fall 2011 developmental mathematics course persistence within financial aid status. Eighty-four percent of Pell Grant recipient students and 48.5% of non-Pell Grant recipient students persisted in Fall 2011 developmental mathematics courses. The contingency table displayed in Table 14 illustrates percent Fall 2011 developmental mathematics course persistence within age. An average of 79% of students aged 20-29 persisted in Fall 2011 developmental mathematics courses, compared to an average of 21% who did not. Fall 2011 persistence for students aged 30-39 averaged 77%, whereas an average of 23% did not persist. For students aged 40-49, Fall 2011 persistence averaged 65%, with an average of 35% not persisting. A majority of students aged 50-59 persisted in Fall 2011 (60%), compared to those that did not (40%). Finally 33% of students aged 60-66 persisted for fall 2011, but an average of 67% of students in the same age range did not persist for fall 2011.

Table 12: Logistic Regression Table - Research Question #2

Variable	B	SE	OR	Wald	95% CI
Constant	1.189	.514	3.284	5.351	
Financial Aid Status	1.789	.252	5.981	50.394	3.650 - 9.799
Age	-.034*	.013	.966	6.616	.941 - .992

* p <.01

Table 13: Percent Fall 2011 Persistence and Financial Aid Status

	Fall 2011 Persistence	
Financial Aid Status	Yes	No
Pell Grant Recipient	84.3%	15.7%
Non-Pell Grant Recipient	48.5%	51.5%

Table 14: Percent Fall 2011 Persistence and Age

	Fall 2011 Persistence	
Age	Yes	No
23	100.0%	0.0%
24	71.4%	28.6%
25	61.1%	38.9%
26	66.7%	33.3%
27	84.2%	15.8%
28	81.8%	18.2%
29	85.7%	14.3%
30	78.6%	21.4%
31	75.0%	25.0%
32	75.0%	25.0%
33	87.5%	12.5%
34	75.0%	25.0%

(continued)

35	53.8%	46.2%
36	71.4%	28.6%
37	81.8%	18.2%
38	100.0%	0.0%
39	75.0%	25.0%
40	50.0%	50.0%
41	66.7%	33.3%
42	54.5%	45.5%
43	72.7%	27.3%
44	71.4%	28.6%
45	81.8%	18.2%
46	60.0%	40.0%
47	85.7%	14.3%
48	50.0%	50.0%
49	61.5%	38.5%
51	33.3%	66.7%
52	33.3%	66.7%
53	60.0%	40.0%
54	75.0%	25.0%
55	75.0%	25.0%
56	100.0%	0.0%
58	50.0%	50.0%
59	50.0%	50.0%
60	100.0%	0.0%
61	33.3%	66.7%
64	0.0%	100.0%
66	0.0%	100.0%

Research question #3 asked how well developmental mathematics course format predicts retention. To answer the question, two separate forward stepwise logistic regressions, using the Wald statistic as criteria for removal, were run using SPSS version 23.0 with each criterion variable (Fall 2011 - fall 2012 semester retention, Fall 2012 - fall 2013 semester retention), and one predictor variable (course format). The regressions focused on retention for the Fall 2011 - fall 2012 semesters, and fall 2012 - fall 2013 semesters, because those semesters fall within the 150% of time completion window defined for the study.

For the first regression focusing on Fall 2011 - fall 2012 semester retention, results indicate that the predictor variable was not retained in the model. This is due to the fact that the Forward: Wald method only retains the significant coefficients. See Table 15.

Table 15: Logistic Regression Table - Research Question #3 - Fall 2011 - Fall 2012 Semester Retention

Variable	B	SE	OR	Sig.	Wald
Constant	.192	.104	1.212	.064	3.436

For the second regression focusing on fall 2012 - fall 2013 semester retention, results again indicate that the predictor variable was not retained in the model. This is again due to the fact that the Forward: Wald method only retains the significant coefficients. See Table 16.

Table 16: Logistic Regression Table - Research Question #3 - Fall 2012 - Fall 2013 Semester Retention

Variable	B	SE	OR	Sig.	Wald
Constant	-.770	.111	.463	.000	48.129

Table 17 displays the correlations between course format, fall 2011 - fall 2012 semester retention, and fall 2012 - fall 2013 semester retention. This revealed a low correlation between the variables, which makes significant prediction impossible, as a relationship between the variables must first exist before a predictive relationship can be an option. The contingency tables below illustrate the lack of a predictive relationship, revealing exactly 50% correct for both retained and not retained for fall 2011 - fall 2012 semester retention (see Table 18), and a range of 48 - 51% both retained and not retained for fall 2012 - fall 2013 semester retention (see Table 19).

Table 17: Research Question #3 - Correlations

	Developmental Education Mathematics Course Delivery Format	Retained 2011FA-2012FA	Retained 2012FA- 2013FA
Developmental Education Mathematics Course Delivery Format	1		
Retained 2011FA-2012FA	.000	1	
Retained 2012FA- 2013FA	-.051	.400*	1

* p < .01

Table 18: Percent Fall 2011 - Fall 2012 Retention and Course Format

Course Format	2011FA-2012FA Retention	
	Not Retained	Retained
Emporium	50.0%	50.0%
Traditional	50.0%	50.0%

Table 19: Percent Fall 2012 - Fall 2013 Retention and Course Format

Course Format	2012FA- 2013FA Retention	
	Retained	Not Retained
Emporium	53.8%	48.2%
Traditional	46.2%	51.8%

Research question #4 asked how well developmental mathematics course format predicts gateway curriculum mathematics course completion. A forward stepwise logistic regression using the Wald statistic as criteria for removal was run using SPSS version 23.0 with one criterion variable (gateway curriculum mathematics course completion) and one predictor variable (developmental mathematics course format). Course format was a significant contributor to predicting gateway curriculum mathematics course completion ($\chi^2 = 7.58$, df =1, p <.01). The Nagelkerke R^2 indicates that this one variable model accounts for 11% of the variance. The Hosmer and Lemeshow Goodness of Fit Test indicates the one variable model is a good fit ($\chi^2 = 0$, df=0). There is not a statistical difference between the observed and predicted number of gateway curriculum mathematics course completion events. This indicates that while this is a statistically significant model, it accounts for only 11% of the variance of gateway curriculum mathematics completion. The remaining variance is accounted for by something other than developmental mathematics course format. Table 20 displays the regression statistics for this model. The logistic equation for this model is:

Gateway curriculum mathematics completion = $1.76 + 1.85_{\text{course format}}$

The odds of completing a gateway curriculum mathematics course are 6.4 times greater if the developmental mathematics course format delivery is traditional. The contingency table displayed in Table 21 illustrates gateway curriculum mathematics course completion within course format. Fifty-four percent of traditional students and 46.4% of emporium students completed the gateway curriculum mathematics course.

Table 20: Logistic Regression Table - Research Question #4

Variable	B	SE	OR	Wald	95% CI
Constant	1.761	.326	5.818	29.109	
Course Format	1.850	.787	6.359	5.519	1.359 - 29.763

Table 21: Percent Gateway Math Course Completion and Developmental Education Math Course Format

	Gateway Math Course Completion	
Course Format	Failed	Passed
Emporium	84.6%	46.4%
Traditional	15.4%	53.6%

Research question #5 asked how well developmental mathematics course format predicts the success of students as measured by transfer or completion of a curriculum terminal degree, diploma or certificate within 150% of normal time, or continued enrollment. To answer the question, a logistic regressions was run using SPSS version 23.0 with one criterion variable (a dummy coded success variable that combined the values of individual transfer, completion, and continued enrollment variables) and one predictor variable (developmental mathematics course format). The regression results indicate that the predictor variable was not retained in the model. This is due to the fact that the Forward: Wald method only retains the significant coefficients. See Table 22.

Table 22: Logistic Regression Table - Research Question #5

Variable	B	SE	OR	Wald
Constant	-.203	.104	.816	3.827

Table 23 displays the correlations between course format and success. This revealed a low correlation between the variables, which makes significant prediction impossible, as a relationship between the variables must first exist before a predictive relationship can be an option. The contingency Table 24 illustrates the lack of a predictive relationship, revealing a range of 44 - 58% for success or no success.

Table 23: Research Question #5 - Correlations

	Success	Developmental Education Mathematics Course Delivery Format
Success	1	
Developmental Education Mathematics Course Delivery Format	-.027	1

Table 24: Percent Success and Developmental Education Mathematics Course Delivery Format

	Success	
Course Format	No	Yes
Emporium	53.7%	46.3%
Traditional	56.4%	43.6%

Summary

Chapter 4 presented the results of this study, which was conducted to find predictors of academic success, persistence, retention, and completion for students enrolled in developmental education mathematics courses utilizing an accelerated emporium model learning environment. The study included students who enrolled in traditional- or emporium-format sections of developmental mathematics courses during the spring 2011 semester. Descriptive statistics were used to provide a demographic analysis of students. The data analysis consisted of a series of logistic regressions to determine if any significant differences existed between the predicator and criterion variables. The results of the logistic regressions indicated that, for research question #1, course format and financial aid status together accounted for less than 10% of the variance of developmental mathematics course completion. None of the other predictors were significant in the regression model. The odds of completing the developmental mathematics course were 2.6 times greater if the delivery was traditional and 2.4 times greater if financial aid status was Pell Grant recipient. For research question #2, financial aid status and age together accounted for 21% of the variance of Fall 2011 developmental mathematics course persistence. None of the other predictors were significant in the regression model. The odds of persisting in a Fall 2011 developmental mathematics course were 5.98 greater if financial aid status was Pell Grant eligible, and only .97% as likely to persist for each one-year age increase. For research question #3, the predictor variables of Fall 2011 - Fall 2012 semester retention and Fall 2012 - Fall 2013 semester retention were not retained in the SPSS regression model. The contingency tables indicated the lack of a predictive relationship between the predictor and criterion variables. For research question #4, developmental mathematics course format accounted for 11% of the variance of gateway curriculum mathematics completion. The odds of completing a gateway curriculum mathematics course were 6.4 times greater if the developmental mathematics course format delivery was traditional. For research question #5, the predictor variable of developmental mathematics course format was not retained in the SPSS regression model. The contingency tables indicated the lack of a predictive relationship between the predictor and criterion variables.

CHAPTER 5: SUMMARY/CONCLUSIONS/RECOMMENDATIONS

Introduction

The purpose of this study was to find predictors of academic success, persistence, retention, and completion for students enrolled in developmental education mathematics courses utilizing an accelerated emporium model learning environment. The sample of convenience included 376 students who either enrolled in traditional- or emporium-format sections of developmental mathematics courses during the semester under study. The researcher utilized logistic regression to answer all of the research questions. The goal of this study was to investigate strategies that hold the most promise for moving students through developmental education mathematics courses.

This study addressed the following research questions: 1) How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict developmental mathematics course completion; 2) How well do course format, student demographics, course instructor employment status, and course instructor length of employment predict first-to-second-semester developmental mathematics course persistence; 3) How well does developmental mathematics course format predict retention; 4) How well does developmental mathematics course format predict gateway curriculum mathematics course completion; and 5) How well does developmental mathematics course format predict the success of students as measured by transfer, completion of a curriculum terminal degree, diploma or certificate within 150% of normal time, or continued enrollment. This chapter provides a discussion of the research findings within the context of the previously reviewed literature, as well as recommendations for policy/practice and future research.

Discussion and Conclusions

This section discusses the results of this research study by viewing those results through the lens of the literature that was reviewed and cited in chapter two. The *ex post facto*, nonexperimental design of this study limits generalization of the results to the larger population. Therefore, the goal is to identify those larger, instructional trends focusing on computer-assisted instruction in general, and the emporium model in particular, as a means of adding to the overall body of research in this area. The information which follows is organized by research question, with earlier studies compared to the current one, in order to identify findings that reach the same or different conclusions.

The findings from research question #1 indicate that course format and financial aid status together accounted for less than 10% of the variance of developmental mathematics course completion. The odds of completing the developmental mathematics course were 2.6 times greater if the delivery was traditional and 2.4 times greater if financial aid status was eligible. These findings differ from the study by Berryman & Short (2010), which found increased levels of academic success for students taking developmental mathematics course utilizing computer-assisted instruction. Charters (2013) also found the emporium model was more effective than the traditional model at helping students complete the developmental math sequence. The work of Robinson

(1990) and Toet (1991) also found higher levels of academic success for students in emporium-format courses. This trend of increases in academic success for students taking developmental mathematics courses in computer-assisted delivery formats is also echoed by the work of Armington (2003), Epper and Baker (2009), Golfin et al 2005, and LaManque (2009). These findings get to the heart of this study by showing that traditional course delivery, rather than an emporium learning environment, was the better predictor of developmental mathematics course completion. One reason that these current findings differ so much from previous, similar studies may lie in the different ways in which the emporium courses are implemented. Other possibilities may be: a) how students were placed into classes; b) how well they responded to emporium technology; c) what type of academic support services were available to them outside of the classroom; and d) faculty attitudes regarding emporium course delivery.

The findings from research question #2 indicate that financial aid status and age together accounted for 21% of the variance of Fall 2011 developmental mathematics course persistence. None of the other predictors was significant in the model for research question #2. The odds of persisting in a Fall 2011 developmental mathematics course were 5.98 greater if financial aid status was Pell Grant recipient, and only .97% as likely to persist for each one-year age increase. Hodara’s meta-study of 2011 countered these results by revealing that specific studies with an appropriate methodological rigor showed increases in persistence rates for those students taking developmental mathematic courses with a computer-assisted component. But Bettinger & Long (2009) found statistically significant increases in persistence, much more than the outcome shown here in this study. Bettinger & Long’s findings are also supported by the studies from Rutschow

(2011) and Diaz (2010). The findings of this study are important because they revealed course format as having no significant predictive value for developmental mathematics course persistence, but access to financial aid was a significant predictor. This information points to the precarious economic situation students find themselves in as they attempt to balance the desire for an education with work and life responsibilities.

The findings from research question #3 indicate that the predictor variables of Fall 2011 - Fall 2012 semester retention and Fall 2012 - Fall 2013 semester retention were not retained in the SPSS regression model for research question #3. The contingency tables indicated the lack of a predictive relationship between the predictor and criterion variables. The results from Epper and Baker (2009) counter the findings here by showing increased success and retention rates for computer-assisted sections of developmental mathematics courses, compared to traditional lecture sections. Similar work from Twigg (2003) and the National Center for Academic Transformation (2005) reinforce the findings of Epper and Baker. But Zavaralla & Ignash (2009) support the findings here with a study that found lower retention rates for students enrolled in computer-assisted sections of developmental mathematics courses. These findings are important because they may point to other factors outside of the classroom which impact student retention, including personal and economic issues faced by students, and the tendency for many community college students to attend college part-time.

The findings from research question #4 indicate that developmental mathematics course format accounted for 11% of the variance of gateway curriculum mathematics course completion. The odds of completing a gateway curriculum mathematics course were 6.4 times greater if the developmental mathematics course format delivery was traditional. The work of Bahr (2008) differs from these findings by showing a statistically significant level of gateway curriculum mathematics course completion for students coming from developmental mathematics courses with a computer-assisted instruction component. The studies from Brothen & Wombach (2004), Johnson (1996), and Waycaster (2011) further support Bahr, with the additional provision that continuous enrollment is key. Finally, Vallade (2013) found significant increases in academic success in college-level courses for developmental mathematics students who came from emporium-format courses. The results of this study differ from most of the other studies looking at modes of computer-assisted instruction. These differences may be attributed to the specific technology used, how well faculty were trained in its use, and the student's comfort with technology in the classroom.

The findings from research question #5 indicate that the predictor variable of developmental mathematics course format was not retained in the SPSS regression model for research question #5. The contingency tables indicated the lack of a predictive relationship between the predictor and criterion variables. Vong & Fisher (2013) counter these findings with a study that noted higher success and completion rates for students who came from developmental mathematics courses utilizing a computer-assisted instruction component. But this is countered by Moore, Jensen & Hatch (2002), whose study found a lack of data necessary to draw a connection between developmental mathematics course format and student completion of a degree, diploma or certificate. These study results are important because they focus on activities which take place at the beginning and end of a student's typical matriculation experience. Establishing a relationship between remedial course format and transfer, completion, or continued enrollment may provide practitioners with data needed to create a better early warning system, thus creating academic interventions that will set students on a course for success early on in their academic careers.

Recommendations for Policy/Practice

This study established that developmental mathematics course format and financial aid status was significant in predicting developmental mathematics course completion, while financial aid status and age were significant in predicting developmental mathematics course persistence. Developmental mathematics course format was also significant in predicting gateway curriculum mathematics completion, but it did not predict retention, transfer, completion, or continued enrollment. The implications of these results formed the genesis of the policy/practice recommendations that follow.

- This study did not gather data from the institution under study indicating the amount of professional development given to faculty who taught in the emporium learning environment. This leaves unanswered the question of whether faculty may have benefitted from increased investment in professional development. The software and hardware available for these classrooms is undergoing constant change. This requires a continuous effort to make sure that the available learning technology is being integrated into the classroom pedagogy in a meaningful way.
- Student age and financial aid status showed up in the logistic regression models as a retained variable. It is recommended that this finding be considered by educational institutions, as they look to pinpoint issues which may affect classroom performance. This may take the form of tutoring, supplemental

instruction, and learning communities tied to age and financial aid. Early intervention scenarios centered on these two variables may preempt later academic challenges.

- Bringing classroom instructional models such as emporium from concept to reality requires careful, intentional planning, as well as ongoing decision-making by institutional leaders (Fong & Visher). In light of this study's findings indicating that the emporium course delivery format did not increase completion, retention, persistence, or success odds for students, it is reasonable to inquire as to how this particular emporium pilot was planned, implemented, and evaluated. Other institutions considering such change may wish to consider the results of this study as a cautionary tale, and devise strategies to more carefully and methodically bring new classroom teaching methods online, with features such as a built-in research component that may provide real-time metrics on key students success and achievement variables.
- For those students who arrive at community colleges immediately following their K-12 experiences, it is recommended that collaboration and partnership take place between institutions, with the goal of ensuring that more students graduate from high school college-ready (Collins, 2009; Edgecombe, 2011; Institute for Higher Education Policy, 1998; Kozeracki, 2002; Parker, 2007; Stigler, Givvin, & Thompson, 2010).
- Institutions may benefit from educating students - during orientation and admissions processes - about the type of learning environment they may encounter with computer-assisted instruction. This may assist the student in

selecting the best course delivery format for their needs and abilities. Such an intake model may have assisted the students in this study to better select a course delivery format.

- In light of this study's findings that the traditional course delivery format better predicted gateway curriculum mathematics completion than the emporium format, institutions need to ask themselves if developmental education course redesign, and developmental education department reorganizations, are resulting in the best learning options for all academically underprepared students. Are these changes being driven by a desire to improve to improve success, persistence, retention, and completion, or the need to reduce costs?

Recommendations for Future Research

- This study focused on an institution’s initial implementation of the emporium course delivery format. As such, the study could not take into account emporium improvements which may have been implemented at the institution in the intervening years. For example, the institution under study is currently using an updated version of MyMathLab, which incorporates additional learning features not present during the spring 2011 pilot. In addition, this study did not benefit from the most recent best practices as they relate to research methodologies for assessing emporium course delivery.
- A cost-benefit analysis may be beneficial to institutions looking at implementing course delivery changes similar to those researched in this study, as a way to consider financial expenditures and student success, persistent, retention, and completion.

- Does fear of math, combined with a fear of technology and computers, contribute to findings on student performance in an emporium setting? Future research could consider the learning curve that has to be navigated when adapting to new methods of instruction and classroom practice. In addition, academically underprepared students may lack the necessary self-efficacy and academic discipline that acclimating to new learning environments requires (Cox, 1990).
- According to the 2013 IPEDS data referenced for this study, African American students represented 43% of the total student body, but constituted 55% of students enrolled in the developmental mathematics classes under study. Caucasian students represented 41% of the total student body, but constituted 36% of students enrolled in the developmental mathematics classes under study. The over- and under-representations seen in this study represent a research opportunity focusing on the downstream factors contributing to the numbers of African American students and other minority populations who are funneled into remedial classes, and how those numbers compare to students of other races. In addition, research looking at contextual factors that support and encourage academic success of African American students may have applicability across other institutions.
- A follow-up, longitudinal research study that follows more students may be useful as a means to identify any other predictor variables present either inside or outside the classroom that may be better at predicting student success, persistence, retention, and completion (Mayer et al., 2014; Quint, Jaggars, Byndloss, & Magazinnik, 2013).

- The results of this study indicate a possible opportunity to focus on the connection between computer-assisted instruction and the different ways in which students learn. Are the key features of computer-assisted instruction - such as interactive feedback and guidance - a good fit for all developmental education mathematics students?
- Computer-assisted instruction, by definition, replaces a portion of the traditional student/teacher interaction common in classrooms. This difference, as compared to traditional format instruction, may account for part of this study's finding that traditional course delivery better predicted student performance on some metrics. An avenue for future research may be to look at how this traditional student/teacher interaction is evolving in technology-intensive classrooms, as well as the psychodynamic effects on a student's perceived ability to learn (Kohler, 2012).

Summary

The socio-economic and demographic diversity of the community college student body may only be equaled or exceeded by the range of previous educational experiences and perceived learning styles that these students bring with them into the classroom. Computer-assisted instruction and emporium course delivery formats reflect one strategy being implemented at community colleges aimed at improving student success, persistence, retention, and completion rates, while also preparing students to function in a 21st century digital society.

The results of this study indicated that course format and financial aid status together accounted for less than 10% of the variance of developmental mathematics course completion. Financial aid status and age together accounted for 21% of the variance of Fall 2011 developmental mathematics course persistence. Further, developmental mathematics course format accounted for 11% of the variance of gateway curriculum mathematics completion. Finally, no predictive relationship was found between the predictor variables of Fall 2011 - Fall 2012 semester retention and Fall 2012 - Fall 2013 semester retention, and developmental mathematics course delivery format. The lack of a predictive relationship was also found between developmental mathematics course format and student success as defined by transfer, completion of a curriculum terminal degree, diploma or certificate within 150% of normal time, or continued enrollment.

These findings point to a realization that the process of getting underprepared students to perform at the college level may take an all-of-the-above strategy, as alluded to in chapter two (McMillan et al, 1997; Schwartz & Jenkins, 2007). The long-term solution may not be a single killer app or silver bullet, but rather lots of diverse, institution- and student-specific interventions, which together add up to the most effective solution.

During the past decade, numerous states, as well as organizations such as Achieving the Dream, the Lumina Foundation, and the Bill & Melinda Gates Foundation, have invested time and resources in researching developmental education mathematics at community colleges, in the interest of improving success, persistence, retention, and completion. Yet a 2016 report found that 2/3 of entering community college students are still unprepared for college-level work (Center for Community College Student Engagement, 2016). This report points to computer-assisted instruction in developmental mathematics courses as just one item in a large portfolio of interventions being implemented. It is perhaps by this multi-pronged approach to resolving the developmental education challenge that real success will emerge. As the report states, “a revolution is underway…” (p. 1). Only when the smoke from this revolution clears, will we be able to get a clear picture of what works and does not work in developmental mathematics education.

REFERENCES

Achieving the Dream & Jobs for the Future (2010). *The developmental education initiative: State policy framework & strategy*. Boston, MA: Jobs for the Future. Retrieved from http://www.jff.org/sites/default/files/publications /DEI_State_Policy_Framework.pdf

Adams, W. (2003). *Developmental mathematics: A new approach.* Washington, DC: Mathematical Association of America. Retrieved from http://www.maa.org/developmental-mathematics-a-new-approach

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college*. Washington, DC: US Department of Education. Retrieved from http://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf

Alexander, J. (2013). *Aligning high school and college instruction: Preparing students for success in college level mathematics* (Doctoral dissertation). Available from ProQuest Dissertations & Theses Global. (1511968916). Retrieved from http://search.proquest.com/docview/1511968916?accountid=14605

Altstadt, D. (2012). *Tying funding to community college outcomes: models, tools, and recommendations for states.* Boston, MA: Jobs for the Future. Retrieved from http://www.jff.org/sites/default/files/publications/TyingFunding2CommColleges-042312.pdf

American Association of Community Colleges. (2013). *Voluntary framework of accountability metrics manual version 2.0*. Washington, DC: American Association of Community Colleges. Retrieved from http://vfa.aacc.nche.edu/Documents/VFAMetricsManual.pdf

American Association of Community Colleges. (2012a). *Reclaiming the American dream: community colleges and the nation's future. A report from the 21st-century commission on the future of community colleges.* Washington, DC: American Association of Community Colleges. Retrieved from http://aacc.wpengine.com/wp-content/uploads/2014/03/21stCenturyReport.pdf

American Association of Community Colleges. (2012b). *The voluntary framework of accountability: Developing measures of community college effectiveness and outcomes*. Washington, DC: American Association of Community Colleges. Retrieved from http://vfa.aacc.nche.edu/ Documents/VFAOutcomesReport WebFINAL.pdf

American Association of Community Colleges. (2014). *Empowering community colleges to build the nation's future: An implementation guide*. Washington, DC: American Association of Community Colleges. Retrieved from http://www.aacc21stcenturycenter.org/wp-content/uploads/2014/04/EmpoweringCommunityColleges_final.pdf

Armington, T. (2003). *Best practices in developmental education (2nd ed.).* Kinnelon, NJ: National Association for Developmental Education, Mathematics Special Professional Interest Network.

Attewell, P. A., Lavin, D. E., Domina, T., & Levey, T. (2006). New evidence on college remediation. *Journal of Higher Education, 77*, 886-924.

Bahr, P. (2008). Does mathematics remediation work?: A comparative analysis of academic attainment among community college students. *Research In Higher Education*, *49*, 420-450. doi:10.1007/s11162-008-9089-4

Bahr, P. R. (2007). Double jeopardy: Testing the effects of multiple basic skill deficiencies on successful remediation. *Research in Higher Education*, *48*, 698-725.

Bailey, T. R., & Cho, S.W. (2010). *Developmental education in community colleges*. New York, NY: Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/developmental-education-community-colleges.pdf

Bailey, T., Jeong, D. W., & Cho, S.W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review, 29*, 255-270.

Bargagliotti, A., Botelho, F., Gleason, J., Haddock, J., & Windsor, A. (2012). The effectiveness of blended instruction in core postsecondary mathematics courses. *International Journal for Technology in Mathematics Education, 19*(3), 83-94.

Bendickson, M. M. (2004). *The impact of technology on community college students' success in remedial/developmental mathematics* (Doctoral dissertation). University of South Florida, United States -- Florida. Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3182686).

Berryman, T. G., & Short, P. M. (2010). Leading developmental education redesign to increase student success and reduce costs. *Student Access, Finance, and Success in Higher Education*, *106*, 106-114.

Bettinger, E. P., & Long, B. T. (2009). Addressing the needs of under-prepared students in higher education: Does college remediation work? *The Journal of Human Resources, 44*, 736–771.

Boatman, A., & Long, B. T. (2010). Does remediation work for all students? How the effects of postsecondary remedial and developmental courses vary by level of academic preparation (NCPR Working Paper). New York, NY: Columbia University. Retrieved from http://files.eric.ed.gov/fulltext/ED522879.pdf

Boughan, K., & Clagett, C. (2008). Degree progress measures for community colleges: Analyzing the Maryland model. *Journal of Applied Research in the Community College, 15*, 150-162.

Boylan, H. R. (1983). Is developmental education working? An analysis of research. In H. H. Hild (Ed.), *The national association for remedial and developmental studies in postsecondary education research report (No. 2)*. Boone, NC: Appalachian State University.

Boylan, H. (1995). Making the case for developmental education. *Research in Developmental Education*, *12*(2), 1-4.

Boylan, H. (1999). Developmental education: Demographics, outcomes, and activities. *Journal of Developmental Education*, *23*(2), 2-8.

Boylan, H. (2002). *What works: Research-based practices in developmental education*. Boone, NC: Continuous Quality Improvement Network and the National Center for Developmental Education, Appalachian State University.

Boylan, H. R., & Bonham, B. S. (2011). Developmental mathematics: Challenges, promising practices, and recent initiatives. *Journal of Developmental Education, 34*(3), 2-10.

Boylan, H. R. (2008). How research contributes to access and opportunity around the world. *Journal of Developmental Education*, *32*(1), 2-3.

Boylan, H. R., & Bonham, B. S. (2007). 30 years of developmental education: A retrospective. *Journal of Developmental Education, 30*(3), 2-4.

Boylan, H. R., Bliss, L. B., & Bonham, B. S. (1997). Program components and their relationship to student performance. *Journal of Developmental Education, 20*(3), 2-8.

Bracey, G. W. (1999). Getting along without national standards. *Phi Delta Kappan. 80*(7), 548-549.

Bragg, D. D. (2001). Community college access, mission, and outcomes: Considering intriguing intersections and challenges. *Peabody Journal of Education, 76*, 93-116.

Brothen, T., & Wamback, C. A. (2004). Refocusing developmental education. *Journal of Developmental Education, 28*(2), 16-18, 20, 22, 33.

Brubacher, J. S., & Rudy, W. (1997). Higher education in transition: A history of American colleges and universities. New Brunswick, NJ: Transaction Publishers.

Buzzetto-More, N., & Ukoha, O. (2009). The efficacy of a web-based instruction and remediation program on student learning. *Issues in Informing Science and Information Technology, 6*, 285-298.

Cannon, T. R. (2005). *Student success: A study of computer-assisted instruction versus lecture-based instruction in developmental mathematics at a Tennessee community college* (Doctoral dissertation). The University of Tennessee, United States -- Tennessee. Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3197601).

Capps, J. P. (1984). *Mathematics laboratory and personalized system of instruction: A workshop presentation*. Somerville, NJ: Somerset County College (ERIC Document Reproduction Service No. 246 969).

Carey, K. (2009, May 28). Introducing a remedial program that actually works. *Chronicle of Higher Education.* Retrieved from http://chronicle.com.librarylink.uncc.edu/article/Introducing-a-Remedial-Program/44409/

Carnegie Commission on Higher Education (2014). *Carnegie classification of institutions of higher education*. Retrieved from http://carnegieclassifications.iu.edu/

Carnegie Foundation for the Advancement of Teaching. (2008). *Strengthening pre-collegiate education in community colleges: Project summary and recommendations*. Stanford, CA: Carnegie Foundation for the Advancement of Teaching. Retrieved from http://www.carnegiefoundation.org/ sites/default/files/publications/elibrary_pdf_774.pdf

Carnevale, A. P., & Smith, N. (2010). More than 2 million job vacancies forecast for NE by 2018, but do our workers have what it takes to fill them? *New England Journal of Higher* Education, *1*,1-3.

Carnevale, A. P., Smith, N., & Strohl, J. (2010). *Help wanted: projections of jobs and education requirements through 2018.* Washington, DC: Georgetown University Center on Education and the Workforce. Retrieved from https://cew.georgetown.edu/wp-content/uploads/2014/12/fullreport.pdf

Carpenter, T. G., Brown, W. L., & Hickman, R. C. (2004). Influences of online delivery on developmental writing outcomes. *Journal of Developmental Education, 28*(1), 14-35.

Casazza, M. E. (1999). Who are we and where did we come from? *Journal of Developmental Education, 23*(1), 1-7.

Castator, M. M., & Tollefson, N. (1996). Underprepared students and the college curriculum: Identifying high-risk courses. *Journal of Applied Research in the Community College, 3,* 179-200.

Center for Community College Student Engagement. (2016). *Expectations meet reality: The underprepared student and community colleges, 2016 national report*. Austin, TX: Center for Community College Student Engagement, The University of Texas at Austin. Retrieved from http://www.ccsse.org/docs/Underprepared_Student.pdf

Charters, C. R. (2013). *A comparison of completion times in traditional versus computer-based developmental math programs* (Doctoral dissertation). ProQuest Dissertations and Theses, 128. Retrieved from http://search.proquest.com/docview/1461413134?accountid=14605. (1461413134)

Cho, S.-W., Kopko, E., Jenkins, D., Jaggars, S. S. (2012). *New evidence of success for community college remedial English students: Tracking the outcomes of students in the Accelerated Learning Program (ALP). CCRC Working Paper No. 53*. New York, NY: Community College Research Center, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/publications/ccbc-alp-student-outcomes-follow-up.html

Chung, C. J. (2005). Theory, practice, and the future of developmental education. *Journal of Developmental Education, 28*(3), 2-4, 6, 8, 10, 32-33.

Clery, S. (2006). Keeping informed about achieving the dream data. *Data Notes, 1(6),* 1-3.

Clery, S., Solorzano, B., & Achieving the Dream (2006). Developmental education and student success. *Data Notes, 1*(7), 1-3.

Cohen, A. M., & Brawer, F. B. (2008). *The American community college* (5th ed.). San Francisco, CA: Jossey-Bass.

Cohen, D. (1995). *Crossroads in mathematics: Standards for introductory college mathematics before calculus AMATYC*. Memphis, TN: State Technical Institute at Memphis. Retrieved from http://search.proquest.com/docview/62655027?accountid=14605

Collins, M. L. (2009). *Setting up success in developmental education: How state policy can help community colleges improve student success outcomes*. Boston, MA: Jobs for the Future. Retrieved from http://www.jff.org/sites/default/files/publications/Setting Up_XS_072109.pdf

Committee on Measures of Student Success. (2011). *Committee on measures of student success: A report to secretary of education Arne Duncan.* Washington, DC: U.S. Department of Education. Retrieved from www2.ed.gov/about/bdscomm/list/ cmss-committee-report-final.pdf

Cotton, J. W., Marshall, S. P., Varnhagen, S., & Gallagher, J. P. (1979). Theory of learning mathematics with computer-assisted instruction: Hierarchical and nonhierarchical options. *Behavior Research Methods & Instrumentation, 11,* 139-146.

Cox, G. L. (1990). Characteristics related to student performance in a college remedial self-paced mathematics laboratory. *Resources in Education, 7*(25), 25 - 31.

Cross, K. P. (1976). *Accent on learning*. San Francisco, CA: Jossey-Bass.

D'Amico, M. M., Friedel, J. N., Katsinas, S. G., & Thornton, Z. M. (2014). Current developments in community college performance funding. *Community College Journal of Research and Practice, 38,* 231-241.

Day, P. R. Jr., & McCabe, R. H. (1997). *Remedial education: A social and economic imperative*. Washington, DC: American Association of Community Colleges.

Dellow, D. A. & Romano, R. M. (2002). Editor's choice: Measuring outcomes: Is the first-time, full-time cohort appropriate for the community college? *Community College Review, 30*(2), 42-54.

Diaz, C. R. (2010). Transitions in developmental education: An interview with Rosemary Karr. *Journal of Developmental Education, 34(1),* 20-25

Dimsdale, T., Kutner, M., & American Institutes for Research, Washington, D.C. (2004). *Becoming an educated consumer of research: A quick look at the basics of research methodologies and design.* Washington, D.C.: The American Institutes for Research. Retrieved from http://www.air.org/sites/default/files/ downloads/report/ Becoming_an_Educated_Consumer_of_Research_0.pdf

Dotzler, J. J., Jr. (2003). A note of the nature and history of post-secondary developmental education in America. *Mathematics and Computer Education, 37*, 121-125.

Dougherty, K. J. (1994). *The contradictory college: The conflicting origins, impacts, and futures of the community college*. Albany, NY: State University of New York Press.

Dumont, R. G., & And, O. (1981). *Evaluating the quality of basic skills programs*. Denver, CO: AIR Forum 1981 Paper. (ERIC Document Reproduction Service No. ED 220 051).

Dyer, R., Reed, P., & Berry, R. (2006). Investigating the relationship between high school technology education and test scores for algebra I and geometry. *Journal of Technology Education, 17*(2), 7-17.

Echenique, M. L. (2007). *Predicting success rate of first-time college students enrolled in developmental mathematics courses in an urban multi-campus community college based on reading level and order of courses taken* (Doctoral dissertation). Available from ProQuest Dissertations & Theses Global. (304850037). Retrieved from http://search.proquest.com/docview/304850037?accountid=14605

Eckart, J. A. (1984). *An investigation of the effectiveness of teaching remedial mathematics in the community college setting under two instructional strategies* (Doctoral dissertation). ProQuest Dissertations and Theses, 143-143 p. Retrieved from http://search.proquest.com/ docview/303307041?accountid=14605. (303307041)

Edgecombe, N. (2011). *Accelerating the academic achievement of students referred to developmental education*. New York, NY: Community College Research Center. Retrieved from http://files.eric.ed.gov/fulltext/ED516782.pdf

Education Commission of the States. (2002). *State policies on community college remedial education: Findings from a national survey*. Denver, CO: Education Commission of the States. Retrieved from http://www.ecs.org/clearinghouse/40/81/4081.pdf

Education Commission of the States. (2014). *A cure for remedial reporting chaos: Why the U.S. needs a standard method for measuring preparedness for the first year of college*. Denver, CO: Education Commission of the States. Retrieved from http://www.ecs.org/docs/Cure-for-Remedial-Reporting-Chaos.pdf

Epper, R. M., & Baker, E. D. (2009). *Technology solutions for developmental math: An overview of current and emerging practices*. Seattle, WA: Bill & Melinda Gates Foundation. Retrieved from: https://docs.gatesfoundation.org/ Documents/technology-solutions-for-developmental-math-jan-2009.pdf

Erickson, K. (2013). *Effectiveness of teaching formats on developmental mathematics achievement* (Doctoral dissertation). ProQuest Dissertations and Theses, 89. Retrieved from http://search.proquest.com/docview/ 1352753236?accountid=14605. (1352753236)

Ewell, P. T. (2011). Accountability and institutional effectiveness in the community college. *New Directions for Community Colleges*, *2011*(153), 23-36. doi:10.1002/cc.434

Fain, P. (2012, July 24). Forks in the road. *Inside High Ed*. Retrieved from https://www.insidehighered.com/news/2012/07/24/large-numbers-students-transfer-community-colleges-four-year-institutions

Fain, P. (2013, June 5). Remediation if you want it. *Inside Higher Ed*. Retrieved from https://www.insidehighered.com/news/2013/06/05/florida-law-gives-students-and-colleges-flexibility-remediation

Flannery, M. E. (2014, October 27). Another lousy 'reform' idea: Eliminating remedial education. *neaToday*. Retrieved from http://neatoday.org/2014/10/15/another-lousy-reform-idea-eliminating-remedial-education

Fong, K., & Visher, M.G. (2013). *Fast forward: A case study of two community college programs designed to accelerate students through developmental math*. New York, NY: MDRC. Retrieved from http:// http://www.mdrc.org/publication/fast-forward

Garson, G. D. (2012). *Logistic regression: Binary & multinomial.* Asheboro, NC: Statistical Associates Publishers.

Gerlaugh, K., Thompson, L., Boylan, H., & Davis, H. (2007). National study of developmental education II: Baseline data for community colleges. *Research in Developmental Education, 20*(4). Retrieved from http://ncde.appstate.edu/sites/ncde.appstate.edu/files/RiDE%2020-4.pdf

Golfin, P., Jordan, W., Hull, D., & Ruffin, M. (2005). *Strengthening mathematics skills at the postsecondary level: Literature review and analysis.* Washington, DC: CNA. Retrieved from: https://www.cna.org/sites/default/files/IPR11659.pdf

Grable, J. R. (1988). Remedial education in Texas two-year colleges. *Journal of Developmental Education, 12*(2), 2.

Grunder, P. G., & Hellmich, D. M. (1996). Academic persistence and achievement of remedial students in a community college's success program. *Community College Review*, *24*(2), 21-33.

Hadden, C. (2000). The ironies of mandatory placement. *Community College Journal of Research and Practice, 24*, 823-838.

Haertel, G. D., & Means, B. (2003). *Evaluating educational technology: Effective research designs for improving learning*. New York, NY: Teachers College Press.

Hassel, H., Klausman, J., Giordano, J.O., O'Rourke, M., & Roberts, L. (2015). TYCA white paper on developmental education reforms. *Teaching English in the Two Year College*, *42*(3), 227-243.

Hattie, J. (2013). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. London: Routledge.

Hector, J. H. (1983). *A base rate approach to evaluating developmental mathematics and English courses at a community college.* (ERIC Document Reproduction Service No. 424861153). Retrieved from http://search.proquest.com/docview /63502140?accountid=14605

Hennessy, J. (2002). Teaching mathematics and science. *The CQ Researcher*, 12, 697-720.

Hern, K. (2010). *Exponential attrition and the promise of acceleration*. Berkeley, CA: Research and Planning Group of the California Community Colleges. Retrieved from http://rpgroup.org/system/files/Hern%20Exponential%20Attrition.pdf

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. *Second Handbook of Research on Mathematics Teaching and Learning, 1*, 371-404.

Higbee, J. L., Arendale, D. R., & Lundel, D. B. (2005). Using theory and research to improve access and retention in developmental education. *New Directions for Community Colleges, 129*, 5-15.

Hodara, M. (2011). *Reforming mathematics classroom pedagogy: Evidence-based findings and recommendations for the developmental math classroom.* New York: Community College Research Center.

Howell, D. C. (2011). *Statistical methods for psychology* (8th ed.). Belmont, CA: Wadsworth Cengage Learning.

Huck, S. W. (2012). *Reading statistics and research*. Boston, MA: Pearson.

Hughes, R. E., & Nelson, C. H. (1991). Placement scores and placement practices: An empirical analysis. *Community College Review, 19*(1), 42-46.

Institute for Higher Education Policy (1998). *College remediation. What it is. What it costs. What's at stake*. Washington DC: Institute for Higher Education Policy. Retrieved from http://files.eric.ed.gov/fulltext/ED429525.pdf

Jacobson, E. (2006a). Computer homework effectiveness in developmental mathematics. *Journal of Developmental Education, 29*(3), 2-6.

Jacobson, E. (2006b). Higher placement standards increase course success but reduce program completion. *The Journal of General Education, 55*, 138-159.

Jaggars, S., Bailey, T., & Columbia University, C. (2010). *Effectiveness of fully online courses for college students: Response to a department of education meta-analysis*. New York, NY: Community College Research Center, Columbia University.

Jenkins, D., Jaggars, S. S., & Roska, J. (2009). *Promoting gatekeeper course success among community college students needing remediation: Findings and recommendations from a Virginia study*. New York, NY: Community College Research Center, Columbia University. Retrieved from http://knowledgecenter.completionbydesign.org/sites/default/files/117%20Jenkins%202009.pdf

Johnson, D. L. (1981). Evolution of a truly individualized program. *Community and Junior College Journal, 52*(4), 14-16.

Johnson, L. F. (1996). Developmental performance as a predictor of academic success in entry-level college mathematics. *Community College Journal of Research and Practice, 20*, 333-344.

Johnson, S. D., & Aragon, S.R. (2000). Comparative analysis of learner satisfaction and learning outcomes in online and face to face learning environments. *Journal of Interactive Learning Research, 11*, 29-49.

Jones, S. (2012). *Remediation: Higher education's bridge to nowhere.* Indianapolis, IN: Complete College America. Retrieved from http://completecollege.org/docs/CCA-Remediation-final.pdf

Jones, S. W. (1986). No magic required: Reducing freshman attrition at the community college. *Community College Review, 14*(2), 14-18.

Kinney, D., & Robertson, D. (2003). Technology makes possible new models for delivering developmental mathematics instruction. *Mathematics and Education, 37*, 315-318.

Kinney, D. P., Stottlemyer, J., Hatfield, J., & Robertson, D. F. (2004). A comparison of the characteristics of computer-mediated and lecture students in developmental mathematics. *Research & Teaching in Developmental Education, 21*(1), 14-28.

Koch, L. C. (1992). Revisiting mathematics. *Journal of Developmental Education*, *16*(1), 12.

Kohler, E. M. (2012). Considering a technological redesign of developmental mathematics? It's sixes. *NADE Digest, 6*(10), 25–37.

Kolajo, E. (2004). From developmental education to graduation: A community college experience. *Community College Journal of Research and Practice, 28,* 365-371.

Konkel, D. (2014). *New college transfer options save time and money*. Chapel Hill, NC: University of North Carolina. Retrieved from https://www.northcarolina.edu/?q=content/new-college-transfer-options-save-time-and-money

Kozeracki, C. (1999). Scratching the surface: Distance education in the community colleges. *New Directions for Community Colleges, 108,* 89-98.

Kozeracki, C. A. (2002). Issues in developmental education. *Community College Review, 29*(4), 83-100.

Krejcie, R.V. & Morgan, D.W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement, 30,* 3, 607-610.

Kuh, G. D., Kinzie, J., Buckley, J. A., Bridges, B. K., & Hayek, J. C. (2006). *What matters to student success: A review of the literature commissioned report for the national symposium on postsecondary student success: Spearheading a dialog on student success*. Washington DC: National Postsecondary Education Cooperative.

Kulik, C.-L. C., & Kulik, J. A. (1991). Effectiveness of computer-based instruction: An updated analysis. *Computers in Human Behavior, 7,* 75-94.

LaManque, A. (2009). Evaluating a non-randomized trial: A case study of a pilot to increase pre-collegiate math course success rates. *Journal of Applied Research in the Community College, 16*(2), 76-82.

Lapez, O. S. (2014). Beyond community college accountability: Using data to investigate best practices for institutional improvement. *Community College Journal of Research and Practice, 38*(1), 86-90.

Lesh, S. G., & Rampp, L. C. (2000). *Effectiveness of computer-based educational technology in distance learning: A review of the literature.* (ERIC Reproduction Service No. ED 440628). Retrieved from http://search.proquest.com/docview/62408659?accountid=14605

Levine, D. R., & Nassau Community College. (1990). *Evaluation of a Two-Year College Remedial/Developmental Mathematics Program*. (ERIC Document Reproduction Service No. ED 325 188).

Lipika, D., & Lieberman, J. (2013). An effective model for teaching developmental mathematics. *Journal of Mathematical Sciences & Mathematics Education*, *8*(1), 48-61.

Lipsett, T. (1986). *The effects of two instructional interventions in mathematics anxiety on achievement of remedial college students* (Doctoral dissertation). Available from ProQuest Dissertations & Theses Global. (303460729). Retrieved from http://search.proquest.com/docview/303460729?accountid=14605

Liston, C. (2014). *Developmental Education Initiative.* Raleigh, NC: NC Community College System. Retrieved from http://www.successnc.org/ initiatives/developmental-education-initiative

Lovell, L., & Fletcher, R. R. (1989, INSERT MONTH). *RDS mathematics as a predictor of college mathematics*. Paper presented at the Annual Meeting of the Tennessee Academy of Science, Nashville, TN.

Lucas, M. S., & McCormick, N. J. (2007). Redesigning mathematics curriculum for underprepared college students. *The Journal of Effective Teaching, 7*(2), 36-50.

Lumina Foundation. (2013). *Strategic Plan: 2013-2016.* Indianapolis, IN: Lumina Foundation. Retrieved from http://www.luminafoundation.org/files/file/2013-lumina-strategic-plan.pdf

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: A longitudinal panel analysis. *Journal of Adolescence*, *27*, 165-179.

Marra, A. (May 27, 2014). CTCs helping students get out of developmental 'quicksand.' *WV Public Broadcasting*. Retrieved from http://wvpublic.org/post/ctcs-helping-students-get-out-developmental-quicksand

Martin, W. E. (1998). *Brown v. board of education: A brief history with documents*. Boston, MA: Bedford/St. Martin's.

Marwick, J. (2002). *Charting a path to success: How alternative methods of mathematics placement impact the academic success of community college students (Doctoral dissertation).* University of Illinois at Urbana-Champaign, United States -- Illinois. Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 3070381).

Maxwell, M. (1991). The effects of expectations, sex, and ethnicity on peer teaching. *Journal of Developmental Education, 15*(1), 14.

Maxwell, W. E. (1979). *Improving Student Learning Skills*. San Francisco, CA: Jossey Bass Publishers.

Mayer, A., Cerna, O., Cullinan, D., Fong, K., Rutschow, E. Z., Jenkins, D., Manpower Demonstration Research Corporation, & Columbia University. (2014). *Moving ahead with institutional change: Lessons from the first round of Achieving the Dream community colleges*. New York, NY: MDRC. Retrieved from http://files.eric.ed.gov/fulltext/ED546648.pdf.

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

McCabe, R., & Day, P. (1998). *Developmental education: A twenty-first century social and economic imperative*. Mission Viejo, CA: League for Innovation in the Community College.

McCoy, K. R., & Prince George's Community College. (1991). *An analysis of developmental students in fall 1990*. Report EA91-11. (ERIC Document Reproduction Service No. ED 330 406).

McCusker, M. (1999). ERIC review: Effective elements of developmental reading and writing programs. *Community College Review, 27*(2), 93.

McMillan, V. K., Parke, S. J., & Lanning, C. A. (1997). Remedial/developmental education approaches for the current community college environment. *New Directions for Community Colleges, 97*(100), 21-32.

Melguizo, T., Hagedorn, L., & Cypers, S. (2008). Remedial/developmental education and the cost of community college transfer: A Los Angeles county sample. *Review of Higher Education, 31*, 401-431.

Merseth, K. K. (2011). Update: Report on innovations in developmental mathematics—moving mathematical graveyards. *Journal of Developmental Education, 34*(3), 32-39.

Middleton, J. A., & Spanias, P. A. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the research. *Journal for Research in Mathematics Education, 30*(1), 65-88.

Miller, M. T., Pope, M. L., & Steinmann, T. D. (2005). A profile of contemporary community college student involvement, technology use, and reliance on selected college life skills. *College Student Journal, 39*, 596-603.

Mills, M. (1998). From coordinating board to campus: Implementation of a policy mandate on remedial education. *Journal of Higher Education, 69*, 672-697.

Moltz, D. (2009. *The new reverse transfer.* Retrieved from https://www.insidehighered.com/ news/2009/02/18/reverse

Moore, C. K. (2014). *Predicting the success of remedial students in college English and mathematics in community colleges based on selected variables* (Doctoral dissertation). Available from ProQuest Dissertations & Theses Global. (1534151673). Retrieved from http://search.proquest.com/docview/1534151673?accountid=14605

Moore, R., Jensen, M., & Hatch, J. (2002). The retention of developmental education students at four-year and two-year institutions. *Research and Teaching in Developmental Education*, *19*(1), 5-13.

National Association for Developmental Education (NADE). (2013). *About developmental education.* Boone, NC: National Association for Developmental Education. Retrieved from http://www.nade.net/aboutdeved.html

National Center for Academic Transformation (2005). *Program in Course Redesign (PCR)*. Sarasota Springs, NY: National Center for Academic Transformation. Retrieved from http://www.thencat.org/PCR.htm

National Center for Academic Transformation (2012). *Changing the equation: Redesigning developmental math*. Saratoga Springs, NY: National Center for Academic Transformation. Retrieved from http://www.thencat.org/Mathematics/CTE/CTE.htm

National Center for Academic Transformation (2012a). *The Emporium Model*. Saratoga Springs, NY: National Center for Academic Transformation. Retrieved from http://www.thencat.org/PlanRes/R2R_Model_Emp.htm

National Center for Academic Transformation (2012b). *Tennessee Board of Regents: Developmental studies redesign initiative*. Saratoga Springs, NY: National Center for Academic Transformation. Retrieved from http://www.thencat.org/States/TN/Abstracts/JSCC%20Algebra_Abstract.htm

National Center for Education Statistics (2012). *An overview of classes taken and credits earned by beginning post-secondary students.* Washington, DC: U.S. Department of Education. Retrieved from http://nces.ed.gov/pubs2013/2013151rev.pdf

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: National Council of Teachers of Mathematics.

Nawrocki, K., Baker, E., & Corach, K. (2009). *Success of remedial math students in the Colorado community college system: A longitudinal study*. Denver, CO: Colorado Community College System. Retrieved from https://www.cccs.edu/wp-content/uploads/2013/09/Success-of-Remedial-Math-Students.pdf

Noel-Levitz. (2008). *Student success in developmental math: Strategies to overcome a primary barrier to retention.* Denver, CO: Noel-Levitz. Retrieved from http://www.noellevitz.com/

Ohio Association of Community Colleges (2013). Impact student success: Recommended proven policies & practices for developmental education. *OACC 2013 Developmental Education Task Force*. Retrieved from http://www.ohiocommunitycolleges.org.php53-13.dfw1-2.websitetestlink.com/pdf/ISS.pdf

Olusi, F. I. (2008). Using computers to solve mathematics by junior secondary school students in Edo state Nigeria. *College Student Journal, 42*(3).

Pampel, F. C. (2000). *Logistic regression: A primer*. Thousand Oaks, CA: Sage Publications.

Parker, T. L. (2007). Ending college remediation: Consequences for access and opportunity. *ASHE/Lumina Fellows Policy Brief Series, 2*. Retrieved from http://files.eric.ed.gov/fulltext/ED530578.pdf

Pascarella, E. T., & Terenzini, P. T. (2005). *How college affects students: A third decade of research*. San Francisco, CA: Jossey-Bass.

Pearson Education. (2014). *MyMathLab product overviews*. New York, NY: Pearson Education. Retrieved from http://www.pearsonmylabandmastering.com/northamerica/mymathlab/

Percy, V. R., & Smith, R. M. (1982). *The use of Rasch ability estimates for English and mathematics placement*. Paper presented at the Annual Meeting of the National Council on Measurement in Education, New York, NY.

Perez, S. (1997). *The relationship of computer-based instructional technology and academic success for students in developmental English programs* (Doctoral dissertation). The University of Texas at Austin, United States -- Texas. Retrieved from Dissertations & Theses: Full Text. (Publication No. AAT 9802990)

Perez, S., & Foshay, R. (2002). Adding up the distance: Can developmental studies work in a distance learning environment? *T H E Journal, 29*(8).

Phipps, R. A., Merisotis, J. P., Institute for Higher Education Policy, American Federation of Teachers, & National Education Association of the United States. (1999). *What's the difference? A review of contemporary research on the effectiveness of distance learning in higher education*. Washington, DC: Institute for Higher Education Policy.

Porter, A., & Mercer County Community College. (1988). *Mercer county community college remedial program assessment, August 1988: Two year follow-up of the fall 1986 cohort.* Trenton, NJ: Mercer County Community College. Retrieved from http://files.eric.ed.gov/fulltext/ED300053.pdf

Pounds, M. L. (1981). *The derivation of a prediction equation to identify potential dropouts among students initially accepted to an urban university as remedial students* (Doctoral dissertation). ProQuest Dissertations and Theses, 80-80 p.

Retrieved from http://search.proquest.com/ docview/303146118?accountid=14605. (303146118)

Pretlow, J., & Wathington, H.D. (2012). Cost of developmental education: An update of Breneman and Harlow. *Journal of Developmental Education, 36*(2), 3-44.

Price, R. V. (1991). *Computer-aided instruction: A guide for authors*. Pacific Grove, CA: Brooks/Cole.

Quint, J. C., Jaggars, S. S., Byndloss, D., & Magazinnik, A. (2013). *Bringing developmental education to scale: Lessons from the developmental education initiative.* New York, NY: MDRC. Retrieved from http://files.eric.ed.gov/fulltext/ED540696.pdf

Quint, J., Byndloss, D.C., Collado, H., Gardenhire, A., Magazinnik, A., Orr, G., Welbeck, R., & Jaggars, S. S. (2011). *Scaling up is hard to do: progress and challenges during the first year of the achieving the dream developmental education initiative*. New York, NY: MDRC. Retrieved from http://www.mdrc.org/publication/scaling-hard-do

Quirk, K. E. (2005). A comprehensive approach to developmental education. *New Directions for Community Colleges, (129),* 83-92.

Ralls, R. S., Morrissey, S., Schneider, B., Corbell, K., Ingoglia, J., & Mbella, K. (2013). *Performance measures for student success.* Raleigh, NC: North Carolina Community College System. Retrieved from http://www.nccommunitycolleges.edu/ publications/docs/Publications/2013%20 Performance%20Measures%20Report.pdf

Reddy, N. L. (1985). *The impact of developmental coursework on the academic success and persistence of underprepared college students* (high risk, remedial) (Doctoral dissertation). ProQuest Dissertations and Theses, 140-140 p. Retrieved from http://search.proquest.com/docview/ 303411296?accountid=14605. (303411296)

Robinson, P. W. (1990). *A study of the self-paced math lab approach to developmental algebra compared to the traditional lecture method at Brenau. Learning theory and applications.* (Doctoral dissertation). ProQuest Dissertations and Theses. Retrieved from http://search.proquest.com/ docview/62971720?accountid=14605

Rotman, J. (2012). *Acceleration in developmental mathematics.* Retrieved from http://www.devmathrevival.net/?p=1568

Roueche, J. E. (1981). Transfer and attrition points of view: Don't close the door. *Community and Junior College Journal, 52*(4), 21-23.

Roueche, J. E., & Roueche, S. D. (1993). *Between a rock and a hard place: The at-risk student in the open-door college*. Washington, DC: Community College Press.

Roueche, J. E., & Roueche, S. D. (1999). *High stakes, high performance: Making remedial education work*. Washington, DC: American Association of Community Colleges.

Roueche, S. (1983). Elements of program success: Report of a national study. *New Directions for College Learning Assistance: A New Look at Successful Programs.* San Francisco, CA: Jossey-Bass.

Rounds, J. C., & Andersen, D. (1985). Placement in remedial college classes: Required vs. Recommended. *Community College Review, 13*(1), 20-27.

Rutschow, E. Z., & Schneider, E. (2011). *Unlocking the gate: What we know about improving developmental education*. New York, NY: MDRC. Retrieved from http://files.eric.ed.gov/fulltext/ED521471.pdf

Rutschow, E. Z., Manpower Demonstration Research Corporation, & Columbia University. (2011). *Turning the tide: Five years of achieving the dream in community colleges*. New York, NY: MDRC. Retrieved from http://academiccommons.columbia.edu/download/fedora_content/download/ac:172366/CONTENT/turning-tide-achieving-dream.pdf

Saade, R. (2003). Web-based educational information system for enhanced learning, EISEL: Student assessment. *Journal of Information Technology Education, 2,* 267-277.

Schrag, P. (1999). End of the second chance? *American Prospect, 99,* 44.

Schwartz, W., & Jenkins, D. (2007). *Promising practices for community college developmental education: A discussion resource for the Connecticut community college system*. New York, NY: Community College Resource Center, Teachers College, Columbia University. Retrieved from http://ccrc.tc.columbia.edu/media/k2/attachments/promising-practices-developmental-education.pdf

Seal, J. F. (2008). *A comparison of academic achievement and retention of community college students in college algebra after completion of traditional or technology-based instruction* (Doctoral dissertation). ProQuest Dissertations and Theses, 92. Retrieved from http://search.proquest.com/docview /304528855?accountid=14605. (304528855).

Seymour, S., & Academic Senate for California Community Colleges. (2009). *Promising practices for transitioning students from adult education to postsecondary education: a review of literature with implications for California community* *college practitioners*. Sacramento, CA: Academic Senate for California Community Colleges. Retrieved from http://basicskills.publishpath.com/websites /basicskills/images/promising-practices.pdf

Shaw, K. M., & London, H. B. (2001). Culture and ideology in keeping transfer commitment: three community colleges. *Review of Higher Education, 25(*1), 91-114.

Sherer, J., Grunow, A., & Carnegie Foundation for the Advancement of, T. (2010). 90-day cycle: Exploration of math intensives as a strategy to move more community college students out of developmental math courses. *Carnegie Foundation for the Advancement of Teaching*. Retrieved from http://files.eric.ed.gov/fulltext/ED514359.pdf

Simms, J., & Knowlton, D. S. (2008). Ideas in practice: Instructional design and delivery for adult learners. *Journal of Developmental Education, 32*(1), 20-30.

Sinclair Community College (1994). *The impact of developmental education on student progress: A three year longitudinal analysis.* Dayton, OH: Sinclair Community College. Retrieved from http://www.eric.ed.gov/contentdelivery/ servlet/ERICServlet?accno=ED383382

Slavin, R. E., & Karweit, N. L. (1985). Effects of whole class, ability grouped, and individualized instruction on mathematics achievement. *American Educational Research Journal, 22,* 351-367.

Smith, D., & Others. (1996). Factors influencing success in developmental math: An observational study. *Research and Teaching in Developmental Education, 13*(1), 33-43.

Spradlin, K., & Ackerman, B. (2010). The effectiveness of computer-assisted instruction in developmental mathematics. *Journal of Developmental Education, 34*(2), 12-18.

Stewart, P. (2012). Closing the math achievement gap: institutions find success with MyMathLab. *Diverse: Issues in Higher Education*, *29*(3), 12-13.

Stigler, J. W., Givvin, K. B., & Thompson, B. J. (2010). What community college developmental mathematics students understand about mathematics. *Mathamatyc Educator, 1*(3), 4-16.

Stuart, R. (2009). Reinventing remedial education. *Diverse: Issues in Higher Education, 26*(18), 14-17.

Swan, B., & Dixon, J. (2006). The effects of mentor-supported technology professional development on middle school mathematics teachers' attitudes and practice. *Contemporary Issues in Technology and Teacher Education, 6*(1), 2-3.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics.* Boston, MA: Pearson Education.

Taylor, J. M. (2008). The effects of a computerized-algebra program on mathematics achievement of college and university freshmen enrolled in a developmental mathematics course. *Journal of College Reading & Learning, 39*(1), 35-53.

Teal, B. D. (2008). *A comparative analysis of modes of instruction using student test scores in developmental mathematics* (Order No. 3314134). Available from ProQuest Dissertations & Theses Global. (304391435). Retrieved from http://search.proquest.com.librarylink.uncc.edu/docview/304391435?accountid=14605

Thiel, T., Peterman, S., & Brown, M. (2008). Addressing the crisis in college mathematics: Designing courses for student success. *Change, 40*(4), 44-49.

Tinto, V. (1987). *Leaving college: Rethinking the causes and cures of student attrition*. Chicago, IL: University of Chicago Press.

Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition* (2nd ed.). Chicago, IL: University of Chicago Press.

Tinto, V. (2006). Research and practice of student retention: What next? *Journal of College Student Retention: Research, Theory & Practice, 8(*1), 1-19.

Toet, J. A. (1991). *A comparative study of two instructional modalities on the achievement level of underprepared community college students* (Doctoral dissertation). ProQuest Dissertations and Theses, 308-308 p. Retrieved from http://search.proquest.com/ docview/303947979?accountid=14605. (303947979).

Townsend, B. K. (2000). Rationales of community colleges for enrolling reverse transfer students: A second chance for whom? *Community College Journal of Research and Practice, 24*(4), 301-311, DOI: 10.1080/106689200264088.

Townsend, B. K. (2001). Redefining the community college transfer mission. *Community College Review, 29*(2), 29-42.

Trenholm, S. S. (2006). A study of efficacy of computer-mediated developmental math instruction for traditional community college students. *Research and Teaching in Developmental Education, 22*(2), 51-62.

Tucker, S. (2002). Distance education: Better, worse, or as good as traditional education? *Online Journal of Distance Learning Administration, 4*(4).

Twigg, C. (2005). *Math lectures: An oxymoron?* Saratoga Springs, NY: The National Center for Academic Transformation. Retrieved from http://www.thencat.org/Newsletters/Jan08.htm#1

Twigg, C. A. (2003). Improving learning and reducing costs: New models for online learning. *Educause Review, 38*(5), 28-39.

Twigg, C. A. (2011). The math emporium: Higher education's silver bullet. *Change, 43*(3), 25-34.

UNC Charlotte (n.d.). *Software*. College of education, Office of information technology. Retrieved from http://oit.uncc.edu/software

U.S. Department of Education, National Center for Education Statistics. (2003). *Remedial education at degree-granting postsecondary institutions in fall 2000* (Statistical Analysis Report No. 2004–010). Washington, D.C.: U.S. Department of Education.

U.S. Department of Education, National Center for Education Statistics. (2014). *IPEDS enrollment survey [Data file]*. Retrieved from http://nces.ed.gov/collegenavigator/?q=Guilford+Technical&s=all&id=198622#general

Vallade, J. K. (2013). *An evaluation of the emporium model as a tool for increasing student performance in developmental mathematics and college algebra* (Doctoral dissertation). ProQuest Dissertations and Theses, 139. Retrieved from http://search.proquest.com/docview/ 1526392838?accountid=14605. (1526392838)

Van Campen, J., Sowers, N., & Strother, S. (2013). *Community college pathways: 2012--2013 descriptive report.* Stanford, CA: Carnegie Foundation for the Advancement of Teaching.

Vandal, B., & Education Commission of the States. (2010). *Getting past go: Rebuilding the remedial education bridge to college success.* Denver, CO: Education Commission of the States.

Wardlaw, R. (1997). *Effect of computer-assisted instruction on achievement outcomes of adults in developmental education programs: A comparative study* (Doctoral dissertation). Available from ProQuest Dissertations & Theses Global. (304388311). Retrieved from http://search.proquest.com/docview/304388311?accountid=14605

Waycaster, P. (2011). Tracking developmental students into their first college level mathematics course. *Inquiry, 16*(1), 53-66.

Weissman, J., Bulakowsi, C., & Jumisko, M. K. (1997). Using research to evaluate developmental education programs and policies. *New Directions for Community Colleges, 100*, 73-80.

Wepner, G. (1985). *Assessment of mathematics remediation at Ramapo college of New Jersey*. Chicago, IL: Paper presented at the meeting of the American Educational Research Association. Retrieved from http://files.eric.ed.gov/ fulltext/ED255377.pdf

Young, J. R. (2005, Month Day). Face-Off: Technology as Teacher? *Chronicle of Higher Education*, *52,* 16.

Zavarella, C. A., & Ignash, J. M. (2009). Instructional delivery in developmental mathematics: Impact on retention. *Journal of Developmental Education, 32*(3), 2-13.

Zhu, Q., & Polianskaia, G. (2007). A comparison of traditional lecture and computer mediated instruction in developmental mathematics. *Research & Teaching in Developmental Education, 24*(1), 63-82.

Zwerling, L. S. (1980). Reducing attrition at the two-year colleges. *Community College Review, 8*(2), 55-