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Developmental Math Education: The Bermuda Triangle of Student Success--Many Enter, but Few Succeed.

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DEVELOPMENTAL MATH EDUCATION
THE BERMUDA TRIANGLE OF STUDENT SUCCESS—
MANY ENTER, BUT FEW SUCCEED

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ABSTRACT

This study employed a quantitative design to evaluate the effectiveness of developmental math and the predictors of student success in developmental math for a period of three years. Four of the study's original eight predictors of student success were statistically significant. However, a model was created using multinomial regression. The model was created using data from the fall 2013 semester and was tested using data from the fall 2014 semester. The effectiveness of developmental math in predicting a student's success in the first college-level math course was tested using a multinomial regression. Although no statistical significance was found, the study did show that students who completed developmental math prior to enrolling in a college-level math course were more likely to earn passing grades. Implications for community college policy, practice, and future research are presented.

CHPATER 1: INTRODUCTION

Problem Statement

The success of students in community college remedial/developmental courses is often an elusive outcome for faculty. In the current higher education environment, community colleges are being tasked with the lion's share of remedial/developmental education when compared to other segments of higher education. This task comes with a high cost for institutions and students. When a student is assigned multiple areas and levels of remediation, the student's ultimate success in college-level courses is not guaranteed (Horn et al., 2009; Bettinger & Long, 2004; Rosenbaum & Person, 2003).

The uncertainty of predicting student success has led to the creation of this research project. The potential to predict student success based on demographic (age, race, gender, first-generation college student, and financial-aid status) and academic factors (number of subject areas requiring remediation, number of required remedial courses, and time to first college-level course) has implications for community colleges in terms of determining where to allocate resources or how best to assist students.

Research Question

What factors influence or affect a remedial student's success in college-level courses? The working hypothesis is the number of subject areas needing remediation and number of remedial courses a student must take before taking the first college-level course will affect the student's success in the college-level course. The operational definition of success is a final grade of "C" or higher. Although previous research has shown the student demographic data (race, age, and gender) plays a role in determining student success (Bettinger & Long, 2005; Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999; and Hoyt, 1999), few studies have focused on the combination of demographic factors, academic readiness, and institutional factors (Fong, Melguizo, & Prather, 2015). This study will contribute to the existing body of literature by examining demographic factors, academic readiness and persistence, and institutional factors to determine what factors are the best predictors of future success.

Demographic factors that will be analyzed include: age, race, sex, if they are first-generation students or members of a special population, and if they are financial-aid recipients. The academic factors that will be analyzed include: number of required remedial math courses (there are two developmental/remedial courses students can be required to take), and time (number of semesters) until college-level course(s) in each remediated subject area.

Academic factors include time to initial developmental math enrollment and academic readiness. According to Fike and Fike (2012), one potential factor in determining student success in developmental math is time to enrollment in the developmental math course (Fike & Fike, 2012). Placement decisions are typically made when a student is admitted to the institution. Students may delay enrolling in developmental courses for one or more semesters. This study will analyze the length of time a student takes from initial enrollment in the institution to enrollment in the initial developmental course to determine if delaying developmental math enrollment impacts student success. Another factor is academic readiness. According to Gallard, Albritton, and Morgan (2010), a student's academic readiness may be the most effective factor for determining student success (Gallard, et al., 2010; Greene, 2000; McCabe & Day, 1998; Reason, 2003). Academic readiness is generally defined as the student's ability to handle the demands of college. These two factors, time to enrollment in the first developmental math course and academic readiness, will be directly addressed in this study in order to evaluate how effective these factors are in determining student success. According to Fong, Melguizo, and

Prather (2015), many of the students assigned to developmental courses may exhibit characteristics associated with a higher probability of dropping out, which is likely to occur before enrolling in a developmental course (Fong, et al., 2015). Due to the likelihood of dropping out because of external or personal factors, this study will begin with a pool of students who have already successfully completed the first college-level math course. From the initial group of students for each cohort (fall 2013, fall 2014, and spring 2015), a dataset will be created that includes each participant's academic history and other demographic variables that will be analyzed to determine what factors contribute to success.

Literature Summary

Community colleges are often described as "revolving door" institutions in the higher education arena (Derby & Smith, 2004). The "revolving door" occurs when students enter community colleges for a variety of reasons, from additional job training to prerequisites for a degree, and leave without obtaining a degree. Since the students are entering for a variety of reasons to pursue a variety of goals, their abilities and motivations also vary. A nationwide study conducted by the National Center for Public Policy and Higher Education in 1999 reveals that instructors and administrators believe the number-one problem facing community colleges today is that too many new students need developmental education (Crews & Aragon, 2007).

Community colleges have a mission to teach students college-level material, although a majority of their students arrive with academic skills in at least one subject area that are too weak to allow the students to successfully engage in college-level work (Bailey, 2009). The purpose of developmental education courses is to prepare students for college-level work by strengthening basic skills. Many students arrive at community colleges requiring developmental education courses in more than one academic area. According to data from the National Education

Longitudinal Study of 1988 (NELS 88) (NCES, 1988), a sample of traditional-aged college students found that 58 percent of the students who attended community colleges took at least one developmental education course. A more recent study from the National Postsecondary Student Aid Study (NPSAS:04) showed that more than half of the students in community colleges enrolled in at least one developmental course during the time they were enrolled in the community college (Horn, Nevill, & Griffith, 2006). Additionally, 44 percent took between one and three developmental education courses. This study also found that 14 percent of the students took more than three developmental education courses. Additional research conducted on developmental education at the community college level concluded that two-thirds or more of community college students enter college with academic skills weak enough in one or more major subject areas to threaten their ability to succeed in college-level courses (Bailey, 2009).

As revealed by the data above, most community college students are not ready for college-level work. Research has indicated that only 10 percent of students who are academically underprepared for college will actually receive a degree (Crews & Aragon, 2007). Crews and Aragon report that 77 percent of developmental education students express the desire to obtain a college degree. There is a great discrepancy between what the students would like (a college degree) and what they actually achieve. Improving a student's chances of completing a college degree must be a priority for community colleges.

Additionally, community colleges and four-year institutions are seeing an increase in the enrollment of students who bring many complicating life issues to the educational setting, including employment and family responsibilities (Crews & Aragon, 2007). Many students enroll in courses at community colleges for reasons other than obtaining a degree. Many are making career changes or preparing for a specific vocation (Burley, Butner, & Cejda, 2001).

According to Burley, et al. (2001), problems involved with entering college for all of these varied reasons are only exacerbated by the additional requirement of having to take developmental education courses (Burley, et al., 2001). As developmental education courses have become an integral part of community colleges, one of the fundamental challenges that confronts these colleges is providing accountability by showing that the developmental education program is both effective and efficient (Kolajo, 2004). States are also beginning to look at the cost of developmental education in relation to the overall effectiveness.

Although many community colleges require students to enroll in developmental education courses, research has shown that often students, faculty, or administrators find ways around the mandatory enrollment. Data from the Achieving the Dream database (2006) reveal a gap between referral to developmental courses and enrollment in these courses. Among the colleges in the Achieving the Dream initiative, about 21 percent of students referred to developmental math did not enroll in any developmental math course within three years of the initial registration in the community college. For developmental reading, the number of students who did not enroll within the three years is 33 percent (Bailey, 2009).

Even when enrollment in developmental education is mandated, developmental education is not always effective (Perin, 2004). Although developmental education and introductory college-level English and math courses are intended to prepare students for the academic demands of postsecondary content-area learning, only one-fourth or less of first-time community college students enroll in these courses (Perin, 2004). According to Bailey (2009), less than one-quarter of community college students in the NELS 88 sample who enrolled in developmental education courses completed a degree or certificate within eight years of enrollment in a community college, while 14 percent transferred to a four-year institution without having completed a degree or certificate (Bailey, 2009). In contrast, almost 40 percent of community college students in the NELS 88 sample who did not enroll in any developmental education course completed a degree in the same time period, with the same 14 percent transferring to a four-year institution without having completed a degree or certificate (Bailey, 2009).

The cost of developmental education is not only monetary. Students pay a personal cost for developmental education; they have a loss of self-esteem and progress more slowly toward graduation (Fong, et al., 2015). As more students have access to higher education, the number of students requiring developmental education and the amount of public resources being spent on providing developmental education has grown at an alarming rate (McMillan, Parke, & Lanning, 1997). Questions arise about why more tax dollars should be spent teaching college students skills they should have acquired in high school (McMillan, et al., 1997). These questions are being asked with a greater sense of urgency in the current economic atmosphere of higher education. Recently, many states have been raising concerns about the cost of providing developmental education (Kolajo, 2004). According to the research of Kolajo (2004), states currently spend approximately $1 billion annually on developmental education. Although the need to control costs for developmental education is evident, the need for a workforce with a solid academic foundation is also apparent (McMillan, et al., 1997). Due to the increasing cost, many states have mandated that developmental education be handled by community colleges only. Additionally, many states are evaluating the effectiveness of developmental education programs. The current body of literature contains numerous research studies that indicate student success in the first college-level math course is not adversely impacted by previous enrollment in developmental/remedial math courses. However, there are numerous studies that indicate enrollment in developmental/remedial math courses does impact student persistence and ultimately degree attainment. The goal of this study is to investigate the impact developmental math courses have on student success in the first college-level math course.

According to the NELS 88 data (NCES, 1988), students who took only one developmental education course performed equally as well as students who did not require any developmental education courses. Kolajo (2004) conducted a research study of community college students and found students taking only one developmental education course had an average GPA of 3.25, took 10 semesters to graduate, and had an average age of 30 at graduation. He compiled the same statistics for two other groups of students: students who took two or more developmental education courses and students who were not required to take developmental education courses. The students who took two or more developmental education courses had an average GPA of 2.86, took 11 semesters to graduate, and had an average age of 27 at graduation. The final group took no developmental education courses, had a GPA of 3.25, took eight semesters to graduate, and had an average age of 25 at graduation (Kolajo, 2004). As age increases, the chances that a student will need to take developmental education courses also increase (Burley, et al., 2001). This is consistent with the findings from Kolajo's study (Kolajo, 2004).

Despite evidence indicating older or nontraditional students will take more developmental courses and have a more difficult time completing a degree, there are successful students who complete developmental education courses. One gap in the literature is the analysis of successful students. Although there is research on students successfully completing one or more developmental courses, the focus has been on the statistics of age, number of developmental courses, and SES (socio-economic status). This study will test a proposed statistical model to predict student success in the first college-level course, based on academic readiness, demographic factors, and institutional factors.

Theoretical Framework

Swail, Redd, and Perna (2003) explored the concept of force-field analysis, based on a psychological environment that can be described mathematically and includes an organized set of constructs that change over time in response to external stimuli (Swail, Redd, & Perna, 2003). "Instead of a linear input-process-outcomes framework, the force-field approach represents the interplay of forces having positive and negative effects on student outcomes" (Hirschy, Bremer, & Castellano, 2011, p. 305). The geometric model developed by Swail et al. (2003) consists of a triangle representing the interactions of cognitive, social, and institutional factors. The triangle symbolizes the overall student experience. One side of the triangle is the cognitive factors, including academic rigor, aptitude, study skills, and time management (Swail, et al., 2003). Although these factors play an important part in student success, this project will not directly address them. As a proxy for academic rigor (readiness), this study will utilize the student's ACT or COMPASS score, which is used to determine course placement. The second side of the triangle is social factors, which include financial issues, maturity, cultural values, and goal commitment (Swail, et al., 2003). As with the cognitive factors, social factors will not be directly measured or addressed by this study due to the complex nature of social factors and how they impact a student's success. Indirectly, financial issues will be addressed through the student's utilization of financial aid, and maturity will be measured through the age of the student. Cultural values will not be directly addressed in this study due to the complex definition of culture. Goal commitment will be indirectly addressed through student persistence. The final side of the triangle consists of institutional factors such as financial aid, student services, curriculum, and instruction (Swail, et al., 2003). This project will address these factors through a general analysis of remedial/developmental education students. The benefit of this model is the ability to analyze factors that can have both positive and/or negative effects on each other and on student success.

Data Collection Methods

Data necessary for the proposed analysis will be collected from the student management system (Banner) at Bayou Community College (BCC), a small rural two-year college located in Louisiana. This analysis will utilize data for students enrolled in the spring semester of 2014. The Banner system will be queried to identify students who were enrolled in MATH 1000 for the spring semester. This will provide a sample of approximately 200 to 300 students who have attempted the first college-level course in math (college algebra). Once these students are identified, prior semester data (courses and grades) for each study participant will be compiled. The goal of data collection is to compile an academic history for each study participant, including all developmental courses and college-level courses taken during his or her career at BCC. Data collected from the Banner database will also include the demographic information and other necessary information to create the desired variables.

Data Analysis Methods

The current study will be conducted on a single college campus. Nora and Cabrera (1996) discussed the benefits of conducting a research study on one campus as opposed to multiple campuses. Conducting a research study in this manner will aid in controlling for several threats to internal validity. Utilizing a single campus means students are more likely to be exposed to similar campus conditions, such as course requirements, teaching faculty, academic staff with whom they must interact, and other institutional elements and conditions (Nora & Cabrera, 1996).

The primary dependent variable in this study is student success (grade of "C" or higher) in college-level algebra (MATH 1000). The following independent variables will be used as controls: age, race, sex, first-generation college student, member of a special population, financial-aid recipient, number of semesters from initial enrollment to first college-level course, number of required remedial courses, academic readiness, and institutional factors such as faculty credentials and faculty teaching status. The primary independent variable will be whether or not students in the study were enrolled in a developmental math course prior to taking MATH 1000.

Two research questions were generated for this study: First, does enrolling in a developmental math course have an impact on success in college algebra. To address this question, a chi-squared design will be utilized. This design is ideally suited for addressing the question of causal relationship between a student's enrollment and successful completion of developmental math and success in college algebra.

The second research question concerns the factors that impact student success in developmental math courses. The dependent variable will be the end-of-course letter grade; the predictors will be the same cognitive, institutional, and social factors listed above. Approximately 200 students should be included in this sample. Due to the nature of the dependent variable, this research question will be analyzed utilizing ordinal regression (Mertler & Vannatta, 2005).

This project will contribute to the existing body of knowledge regarding the effectiveness of developmental math courses and what, if any, impact or effect these courses have on a student's success in the first college-level course. As community colleges grapple with increasing pressure to graduate students who are often underprepared for college, information regarding factors that impact student success would be a tremendous asset. Knowing what factors improve or hinder a student from being successful in the first college-level math course, will lead to the development of policies to guide incoming students.

CHAPTER 2: LITERATURE REVIEW

Introduction

The “revolving door” nature of community colleges creates a different mission for community colleges, as opposed to the mission of four-year institutions (Derby & Smith, 2004). The mission of community colleges is to provide education to students who may have many different goals, from additional job training to prerequisites for a degree. Since the students are entering for various reasons to pursue diverse goals, their abilities and motivations also vary. Data from a National Postsecondary Student Aid Study (NPSAS:04) reveals that over half of public community college students enroll in some form of developmental[1] education course (Horn, Nevill, Griffith, & National Center for Education Statistics, 2006), a reflection of the diverse nature of the population of students served by these institutions.

According to a study completed by Bailey (2009), most community college students arrive with academic skills in at least one subject area that are too weak to allow the students to successfully engage in college-level work (Bailey, 2009). The primary purpose of developmental education courses is to prepare students for college-level work by strengthening basic skills. Many studies have determined that the amount of developmental coursework students are required to complete is associated with a higher dropout rate, which is contrary to the intent of developmental education (Bahr, 2010; Hoyt, 1999).

Crisp and Delgado (2014) identified several differences between developmental math students and college-level math students. Differences were noted in gender, ethnicity, first-

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[1] Developmental education is also referred to as remedial education or remediation. These terms will be used interchangeably.

generation status, academic preparation, high school experiences, and delayed college entry (Crisp & Delgado, 2014). In addition to these factors, developmental students also tend to enroll as part-time students due to financial and family issues (Hoyt, 1999). Student success is dependent on these factors, as well as institutional factors. As such, the following is a review of current relevant literature regarding factors that influence persistence and student achievement.

Previous Research

Bailey, Jeong, and Cho (2010) conducted a multi-state analysis of Achieving the Dream data. The researchers focused on developmental reading and the success of students in the first gatekeeping college-level course. According to Bailey et al. (2010), 72 percent of students who completed the sequence of developmental reading courses to which they were assigned then enrolled in the first college-level English course. From the 72 percent who enrolled, 75 percent successfully completed the course (Bailey et al., 2010).

Three studies have examined multiple institutions within a single state. Long and several colleagues studied all of the students within the study state (Florida, Tennessee, or Ohio) to determine the impact developmental math and reading had on student persistence (Bettinger & Long, 2005; Boatman & Long, 2011; Calcagno & Long, 2008). Calcagno and Long (2008) studied students in Florida's 28 community colleges and found that students taking developmental math courses increased persistence from the first year of college to the second year. Although there was an initial increase in student persistence, Calcagno and Long (2008) found that over time there was either a negative impact or no impact at all (Calcagno & Long, 2008). The Calcagno and Long study focused on students who had placement scores close to the cutoff point to determine if there was a benefit to taking developmental course work. According to the results of this study, any benefit a student might gain in the short-term from developmental coursework, ultimately provides little impact in determining whether or not a student will persist to degree or certification completion.

In addition to multiple institution and multi-state research, several studies focused on a single state with one main outcome. Roksa and colleagues (2009) studied first-time community college students in Virginia to help the community college system improve the proportion of underprepared students who take and pass the first college-level math or English course (Roksa, Jenkins, Jaggars, Zeidenberg, & Cho, 2009). The initial study results found that about 65 percent of students passed the first college-level English course after taking developmental English, while 48 percent of students passed the first college-level math course after taking developmental math (Roksa et al., 2009). The authors discussed how these results are similar for students who were assigned but did not enroll in any developmental courses, instead choosing to enroll directly in the first college-level course (Roksa et al., 2009). Roksa et al. (2009) controlled for individual characteristics and attending institution, and determined that reading and writing placement test scores did not predict whether students passed the first college-level English course (Roksa et al., 2009). After refining the data, the remaining cohort had 50 percent of students completing the first college-level English course, while only 25 percent completed the first college-level math course (Roksa et al., 2009).

One study performed a single institution analysis. Fike and Fike (2008) studied first-time students entering the study institution over a four-year period. This study examined predictors of retention, including factors not previously addressed such as parents' education level, number of credits students enrolled in and/or dropped during the first semester, and participation in TRIO tutoring (Fike & Fike, 2008). The authors were interested in student retention to next term and into the following academic year (Fike & Fike, 2008). The Fike and Fike study (2008) showed that enrollment in developmental education courses and utilization of financial aid contributed to students' persistence during the fall-to-fall and fall-to-spring timeframes (Fike & Fike, 2008). The results were mixed when looking specifically at enrollment in developmental English, reading, and writing courses. The strong predictor of retention was passing developmental reading, while passing a developmental writing course was a predictor for only fall-to-fall retention with no long-term benefit (Fike & Fike, 2008). The Fike and Fike (2008) study utilized a single institution for a limited time frame, placing limitations on the study and making the generalization of results more difficult (Fike & Fike, 2008). In addition, this study provides no long-term data to determine if there are effects from developmental education enrollment later in a student's college career (Fike & Fike, 2008; Bremer, Center, Opsal, Medhanie, Jang, & Geise, 2013).

Strengths and Weaknesses of Previous Research

The study conducted by Bailey et al. (2010) utilized data from Achieving the Dream that includes institutions that serve more minorities, are larger institutions, and have instructional costs that are less than other community colleges. As a result, the dataset does not reflect community colleges in general and, therefore, the results cannot be generalized (Bailey et al., 2010; Bremer, et al., 2013). The authors supplemented the Achieving the Dream dataset with information from the Integrated Postsecondary Education Data System (IPEDS) that included institutional factors and information used as proxy for individual characteristics. Due to the utilization of indirect measures, the authors were unable to determine the impact factors such as individual-level socioeconomic status had on the progression through developmental courses (Bailey et al., 2010). The strength of the Bailey et al. (2010) research is the robustness of the dataset. The Achieving the Dream data included 250,000 students from 57 community colleges in seven states. Additionally, the authors utilized data from the 2000 Census to provide a richer dataset for analysis (Bailey et al., 2010).

Multiple studies conducted by Long and colleagues (2008, 2009, & 2010) utilize data from single states with multiple institutions. All three studies utilize state datasets that include all currently enrolled students, which provided a large and robust dataset. The Boatman and Long (2010) study, conducted in Tennessee, consisted of individual-level data for a period of three academic years. Graduation data were also collected at the six-year point (Boatman & Long, 2010). This study was conducted at both two- and four-year institutions in the state, which means the data are more difficult to generalize regarding the effect of community college developmental education courses. Bettinger and Long (2009) conducted a study of first-time freshmen at all Ohio community colleges. This study excluded data from Ohio's two-year technical colleges (Bettinger & Long, 2009). Although the data are from a single state, Ohio had similar enrollment and developmental education rates, when compared to other states and national levels, that allow for the results to be generalized to the larger population of community colleges (Bettinger & Long, 2009). A strength of this research study is that the authors chose to not compare developmental students to non-developmental students, since better-prepared students are less likely to be assigned developmental coursework and have the skills to be more successful in college-level courses. By comparing only developmental students, the authors are better able to analyze the causal effects of developmental education at institutions with varied placement policies (Bettinger & Long, 2009).

Calcagno and Long (2008) conducted a research study in Florida to determine if students close to placement score cutoffs benefitted from developmental education. This study utilized nearly 100,000 student records to create a robust dataset, including information on test scores, demographic characteristics, previous education (high school diploma, other diploma, or GED), English language ability, educational facilities, curriculum, and educational staff (Calcagno & Long, 2008). A primary strength of this study is the utilization of a large and diverse student group, which provided new insights on several outcomes not previously studied. As with other studies utilizing robust datasets, researchers may have difficulty determining the effect developmental education has on a student's persistence (Calcagno & Long, 2008).

The multi-state study conducted by Bremer et al. (2013) included data from one institution in each participating state. The strength of this study is the ability to examine the data more thoroughly, since there is a richness of data available at a single institution that may not be available across a community college system or from multiple states. In addition, this study provides more generalization of data than a single institution study, while allowing for more in-depth data analysis than a larger study of multiple institutions across multiple states (Bremer et al., 2013). The limitation of this study is that the data did not allow the researchers to determine if the benefit of tutoring was due to the actual tutoring, the impact of developing a personal connection with the tutor, or the actual characteristics of the individual students (Bremer et al., 2013).

The single state research study conducted by Roksa et al. (2009) examined 24,000 first-time community college students from Virginia for a four-year period. The strength of this study is the robustness of the data and timeframe covered by the study. The limitations of this study were the inconsistency in the way placement recommendations are reported and the way the proportion of students recommended to take developmental courses is reported (Roksa et al., 2009). The inconsistencies in the way data are reported makes comparing institutions and drawing conclusions about developmental education more difficult.

The single-institution study conducted by Fike and Fike (2008), examined 9,200 first-time students over a four-year period. This study analyzed academic records to determine predictors of retention (Fike & Fike, 2008). Although the dataset was large, the fact that the study was conducted at a single institution makes generalizing the data difficult. A limitation of this study is that the results may only be generalized to developmental math courses at community colleges (Fike & Fike, 2008). In addition, this study, like many others, was retrospective, and random assignment to developmental courses was not possible. The data analysis indicated that enrollment in and successful completion of developmental courses positively impacted student retention. In terms of employment status, the authors found no difference in student performance. Calcagno et al. (2008) did find an impact of employment status of faculty. When students enroll in degree programs that employed a higher portion of adjunct (part-time) faculty members, students' performance and persistence were negatively affected (Calcagno et al., 2008). However, when analyzing the degree credentials of faculty members, holding a master's degree or higher had a positive impact on student performance in the developmental education course (Calcagno et al, 2008). The authors found a positive relationship for student outcomes when faculty members hold graduate degrees (Fike & Fike, 2008). The effect of developmental education may be the result of instructional practices or institutional policies and, therefore, not generalizable (Fike & Fike, 2008).

Basis for Current Research

In a study conducted by Fong, et al. (2015), student success rates in developmental math were analyzed for the role that individual and institutional characteristics have in student success (Fong et al., 2015). The authors discussed the need for developmental education, based on the percentage of incoming community college freshmen who need developmental education before they can enroll in college-level courses. According to the National Postsecondary Student Aid Study (NPSAS: 04), this percentage is roughly half of the incoming freshmen who needed developmental education in at least one academic area (Horn et al., 2006). According to many studies, the cost of developmental education is a barrier to student success and degree attainment (Melguizo et al., 2014; Strong American Schools, 2008; Fong et al., 2015). The cost is not only financial, but also includes time and effort. Students facing two developmental math courses before being allowed to take the first college-level math course may see the task as too daunting and either not attempt or attempt but quit at the first sign of difficulty (Fong et al., 2015; Bailey, 2009a; Bailey, 2009b). Thus, it is not surprising that current research indicates that the amount of developmental coursework a community college student is required to complete is associated with student drop out (Fong et al., 2015; Bahr, 2010; Hoyt, 1999). Some research indicates that the negative effect developmental education courses have on student persistence may be due to selection bias (Attewell, Lavin, Domina, & Levey, 2006; Bettinger & Long, 2005; Melguizo et al., 2013). Crisp and Delgado (2014) discussed how developmental education students are systematically different from students ready for college-level courses due to their academic preparedness, experiences in high school, and delayed entrance into college (Crisp & Delgado, 2014). In addition, developmental education students are more likely to enroll part-time, as compared to college-ready students. This enrollment may be due to financial obligations or family and work commitments (Hoyt, 1999). Although developmental education students are different, just stating that fact does not provide evidence to indicate what factors play the biggest role in student success.

Not only does developmental education cost students, but the institution also incurs costs for implementing developmental education courses, instructional costs associated with developmental education courses, and the ultimate cost of a student dropping out (Fong et al., 2015). Currently, research indicates that the cost of developmental education is about $2 billion annually (Strong American Schools, 2008). Many community colleges are funded based on completers, so losing students because of developmental education is a cost too high for many institutions.

Although there is ample evidence to suggest that students are not benefitting from developmental education, the alternative is leaving underprepared students to flounder in college-level courses with little or no support or have underprepared students not attend college at all (Lazarick, 1997). There is a national push to increase college degree attainment. As such, improving the percent of developmental education students who successfully complete the required courses has become the top priority for community colleges around the country (Fong et al., 2015). Despite the importance of understanding how and why students are successful, there are actually very few studies that follow successful students to determine what factors influence their ultimate success. Fong et al. (2015) and Bahr (2012) conducted studies focused on measuring only students who actually progressed (attempting and passing) through each developmental course (Fong et al., 2015; Bahr, 2012). Defining progression the way Fong et al. (2015) and Bahr (2012) did provided one insight into a major issue in developmental education: low attempt rates (Fong et al., 2015; Bahr, 2012). Previous studies have not made a distinction between students who did not attempt, students who attempted and were unsuccessful, or students who attempted and were successful. The Fong et at. (2015) and Bahr (2012) studies provide a richer analysis of data to determine the factors of successful developmental education students, instead of grouping all developmental education students together (Fong et al., 2015; Bahr, 2012).

Swail, Redd, and Perna (2003) explored the concept of force-field analysis (Swail, et al., 2003). Instead of a direct input and outcome process, the force-field analysis takes into account the interactions of different factors and how that ultimately affects student outcomes (Hirschy, et al., 2011). The geometric model developed by Swail et al. (2003) consists of a triangle representing the interactions of cognitive, social, and institutional factors. The triangle symbolizes the overall student experience in higher education (Swail et al., 2003). The interplay between factors provides a better understanding of what makes a student successful in college.

The cognitive side of the triangle has academic factors, including academic rigor, aptitude, study skills, and time management (Swail et al., 2003). The Fong et al. (2015) study determined that students enrolled in developmental education courses reported lower high school GPAs, earned fewer college credits during high school (dual enrollment), took lower-level math courses in high school, and delayed entry into college (Fong et al., 2015). In addition, Hagedorn et al. (1999) determined that the amount students studied in high school was related to their success in developmental education courses (Hagedorn, et al., 1999). These individual characteristics are important in determining how prior math abilities, study skills, and time management affect success in developmental math.

The second side of the triangle is social factors, which include financial issues, maturity, cultural values, and goal commitment (Swail et al., 2003). Hoyt (1999) discussed the impact family and job commitment have on the enrollment status (full or part-time), as well as financial obligations that developmental education students experience (Hoyt, 1999). Bremer et al. (2013) found that students pursuing vocational (technical) certifications are more likely to persist through developmental education (Bremer et al., 2013). Although social factors are more elusive to measure, they contain valuable information regarding what influences a student to succeed.

The final side of the triangle consists of institutional factors such as financial aid, student services, curriculum, and instruction (Swail et al., 2003). Institutional factors have not been studied as extensively as other factors. However, Fong et al. (2015), Bahr (2010), and Bailey et al. (2010) conducted studies including institutional factors to determine what institutions do or do not do that impact a student's persistence and ultimate success (Fong et al., 2015; Bahr, 2010; Bailey et al., 2010). Additional institutional factors to include are class size, faculty credentials, and institutional policies. Akerhielm (1995) studied the impact class size has on student achievement. Although there is not consistent evidence concerning the effect class size has on student success, there is evidence to show a benefit of smaller class size for low-achieving students (Akerhielm, 1995). Bailey et al. (2010) suggests that the complexity of the developmental education system may lead students to view the required courses as obstacles. This view can lead students to avoid enrolling in the required courses (Bailey et al., 2010). Fike and Fike (2007) discuss the impact faculty employment status has on student success. The authors suggest that when a faculty member is employed full-time, the students perform better (Fike & Fike, 2007). As the need to improve developmental education increases, knowing what institutional factors impact student success can help institutions better design college policies and implement more effective developmental education programs.

Although research has been conducted on the impact developmental math has on student persistence and success, these studies have not been comprehensive in the study of factors that students and institutions possess that lead to successful completion of gatekeeping college-level courses. Current literature does not exist regarding factors, both institutional and personal, that influence the success a developmental math student has in the first-college level math course. One issue that has been stated in numerous studies deals with the inconsistencies in developmental education policies and how they are enforced. Although developmental education is a requirement, based on student performance (placement test or entrance test), many students find ways around that requirement, essentially making developmental education voluntary (Bailey, 2009a).

Contribution to Existing Literature

This study will analyze student and institutional characteristics to determine what factors contribute to predicting student success in the first college-level math course. The models examined in this study are more comprehensive than those in previous work and focus on a single institution. Additionally, the study will also address factors that contribute to student success in developmental math.

CHAPTER 3: METHODOLOGY

This study utilized a quantitative design consisting of ordinal regression and a chi-square test for independence. The chi-square test for independence design will be utilized to determine the effectiveness of developmental math on a student's success in college algebra. The ordinal regression was utilized to develop a model. The model provided a visualization of the impact different factors had on student success. This chapter addresses the methodology of the research study, including the description of the sample, the data collection methods, the research questions, and the variables.

Community colleges struggle to understand the factors that impact a student's success and, in turn, a student's ability to complete a degree or program. The inability to adequately identify factors related to student success in community colleges creates frustration among administrators, instructors, and students. Additionally, community colleges are being tasked with condensing or removing developmental education courses, sometimes in an effort to reduce the time students spend completing a degree and other times as the result of the debate over effectiveness. The push to have students successfully complete programs, the confusion over what influences student success, and the debate over the effectiveness of developmental education have community colleges exploring questions about the effectiveness of developmental courses and examining alternatives. In light of the changes to developmental education courses, along with the increasing need for community colleges to handle students who are not prepared for college-level courses, more research is needed to identify the factors that improve student success, including the role of developmental education.

Due to the uncertainty of predicting student success, this research project was designed to help institutions better identify the factors that can improve student success rates. The potential to more accurately predict student success, based on demographics (age, race, gender, and financial-aid status), academic factors (high school GPA, overall cumulative GPA, number of subject areas requiring remediation, and time from initial enrollment to developmental math enrollment), and institutional factors (faculty credentials) has implications for community colleges in terms of determining where to allocate resources or how best to assist students.

Research Questions

The goal of this research project was to identify factors related to the academic success of community college students. The focus was on the segment of the community college student population that was required to take developmental education courses, specifically in the area of mathematics. Although previous research has shown the student's demographic data (race, age, and gender) play a role in determining student success (Bettinger & Long, 2005; Hagedorn, et al., 1999; and Hoyt, 1999), few studies have focused on the combination of demographic factors, academic readiness, and institutional factors (Fong, et al., 2015). Examining demographic factors, academic readiness and persistence, and institutional factors to determine what factors were the best predictors of future success was the basis of this research project. In order to examine the above factors, the following research questions were developed.

Research Question One: What are the predictors of success in developmental math?

Design. A correlational design was used to address this question. The sample consisted of students enrolled in the second of the two-course developmental math series (MATH 0084) during the fall 2013 semester. The predictors examined, based on current literature, are listed in Table 1. End-of-course letter grades was the dependent variable. Since this is an ordinal measure, the data were analyzed using ordinal regression. The analysis strategy included the following steps: Data Quality and Assumptions, Model Building, and Assessing Model Adequacy. Step one entailed analyses to ensure that the data were treated accurately and the assumptions of ordinal regression were met. Step two entailed a process of model refinement and formulating as parsimonious a model as possible. Step three focused on the adequacy of the resulting model in explaining variations in end-of-course grades among participants in the study. Step four was the verification of the model, utilizing a dataset of students enrolled in MATH 0084 during the fall 2014 semester.

Table 1
Research Question One Information

Research Question	Data Sources	Statistical Model
Question One: What are the predictors of success in developmental math?	Student Academic History and Transcript Data	Ordinal Regression
	Dependent Variable	Predictors
	End of course performance for MATH 0084: A, B, C, D, or F	1. Time from institutional enrollment to first enrollment in developmental math 2. Enrollment status (full-time/part-time) 3. Areas requiring remediation (English, math, or reading) 4. High school GPA 5. COMPASS/ACT score 6. Demographic factors: Age, race, gender, and financial aid recipient 7. Faculty credentials (BS, MA, etc.) 8. Faculty employment status (full-time or part-time)

Sampling. This study was conducted in a single campus environment. Bayou Community College (BCC) is a small community college with an average enrollment of 1,900 students per semester.

The Banner system was queried to identify students who were enrolled in MATH 0084 during the fall 2013 semester. The dataset included all students who attempted MATH 0084, including students who successfully completed the course, students who failed the course, and students who withdrew from the course. The results created a sample of approximately 200 to

250 students. After compiling the list of all students enrolled in MATH 0084 during the fall 2013 semester, student data for previous semesters (courses and grades) was compiled for each study participant. The goal of data collection was to compile an academic history for each study participant, including all developmental courses and college-level courses taken during his/her career at BCC. The data collected from the Banner database also included the demographic information and other necessary information for all of the study variables. After creating the initial dataset from the fall 2013 semester, a second dataset as created using data from the fall 2014 semester. The same procedures were followed in the creation of the second dataset. This study utilized data from fall 2013 and fall 2014 since the institution made a change to the developmental math curriculum and the course numbers after the spring semester of 2015.

Data analysis. Once the initial dataset, including all study variables, was created for students who attempted MATH 0084 during the fall 2013 semester, all student identifying information was removed and a unique identifier was assigned to track the data throughout the study. The data were entered into SPSS to begin the analysis. An initial model was created using ordinal regression. Once the model was constructed, only predictors that had a significant impact, either positive or negative, were included. Although the existing literature included numerous predictors of student's success in developmental math, this model did not support all of the initial predictors listed in Table 1. The initial model was then verified using data from the fall 2014 semester.

According to the authors of the Laerd Statistics website (Lund & Lund, 2013b), data must meet four assumptions in order for the ordinal regression statistic to provide valid results. The first assumption was that the dependent variable was measured on an ordinal scale. The final course grade was the dependent variable and had five options, A, B, C, D, or F. The second assumption was that one or more of the independent variables (predictors) were either continuous or categorical. The third assumption was that there was no multicollinearity, which occurs when there are two or more independent variables that are highly correlated with each other. When multicollinearity occurs, there can be difficulty understanding which variable contributes to the explanation of the dependent variable. The final assumption was that there are proportional odds, which means that each independent variable had an identical effect at each cumulative split of the ordinal dependent variable. (Lund & Lund, 2013b). Each of these assumptions was assessed and adjustments were made to the analysis, as necessary.

Research Question Two: Does success in a developmental math course predict success in college algebra?

Design. Does success in a developmental math course predict success in college algebra? To address this research question, a chi-square test for independence was utilized. This design was ideally suited for illustrating relationships between variables, in this case, the relationship between success in Math 0084 and success in Math 1000. According to Lund and Lund (2013a), chi-square test for independence was ideally suited for showing the frequency that a possibility occured such as how many students who took Math 0084 successfully completed Math 1000 (Lund & Lund, 2013a). The sample for this analysis consisted of students who have attempted college algebra (Math 1000) in the spring 2015 semester. This sample was coded for those who took a developmental math course prior to taking Math 1000 and those who did not. The analysis strategy included the following steps: Data Quality, Analysis, and Verifying Results. Step one entailed analyses to ensure that the data were treated accurately. Step two entailed conducting the chi-square analysis. Step three focused on the accuracy of the results in explaining the effect of enrollment in a developmental math course. The dependent variable for this analysis was defined as success or failure in college algebra. Success was defined as a grade of "C" or better. All other outcomes were designated as a failed attempt.

Sampling. The Banner system was queried to identify students who were enrolled in MATH 1000 during the spring 2015 semester. The dataset included all students who attempted MATH 1000, which included students who successfully completed the course, students who failed the course, and students who withdrew from the course. This provided a sample of approximately 200 to 250 students. After compiling the list of all students enrolled in MATH 1000 during the spring 2015 semester, student data for previous semesters (courses and grades) was compiled for each study participant. The goal of data collection was to compile an academic history for each study participant, including all developmental courses and college-level courses taken during his/her career at BCC. The data collected from the Banner database also included the demographic information and other necessary information for all of the study variables. Although MATH 1000 is offered every semester, the spring semester was selected to allow students who enrolled in the fall semester time to progress to MATH 1000. Generally, there are more students enrolled in MATH 1000 in the spring semester than enrolled in the fall semester.

Data analysis. For research question two, the initial data was gathered from the students enrolled in all sections of MATH 1000 during the spring 2015 semester. From the initial data, an analysis was conducted to create a dataset, including demographic information, academic history, and institutional factors for each student. After the information was collected, all student identifying information was removed and a unique identifier was assigned to track the data throughout the study. The data was entered into SPSS to begin the analysis.

The chi-square test for independence, also called the Pearson's chi-squared test, has two assumptions. The first assumption is that the two variables are measured at the ordinal or nominal level (Lund & Lund, 2013a). The variables in this study met this assumption. Success in Math 1000 is ordinal and the placement decision is nominal. The second assumption is that the two variables should consist of two or more categorical groups (Lund & Lund, 2013a). The variables in this study each contained more than two categories. Success in Math 1000 has five categories and placement decision has four categories.

When utilizing the chi-square test for independence, there was an assumption of random sampling. This study did not utilize random sampling since the study utilized the entire sample from the spring 2015 semester. Additionally, the participants must be in only one category. In this study, each student only has one placement decision and received only one final course grade in Math 1000. Table 2 contains information regarding research question two.

Table 2
Research Question Two Information

<table>
<tr><th>Research Question</th><th>Data Sources</th><th>Statistical Model</th></tr>
<tr><td rowspan="3">Question Two:

Does success in a developmental math course predict success in college algebra?</td><td>Student Academic History and Transcript Data</td><td>Chi-square test for independence</td></tr>
<tr><td>Dependent Variable</td><td>Predictors</td></tr>
<tr><td>End of course performance for college algebra:
A, B, C, D, or F</td><td>1. Performance in developmental math
2. Placement decision</td></tr>
</table>

Table 3 contains the variables that will be utilized in the analysis of both research questions.

Table 3
Study Variables

Variable Name	Type of Variable	Possible Values
<u>Dependent variable for initial model:</u> Final course grade in developmental math	Ordinal	A, B, C, D, F, or W* * Student withdrew

(Table 3 continued)

Variable Name	Type of Variable	Possible Values
Dependent variable for second model: Final course grade in college algebra	Ordinal	A, B, C, D, F, or W* * Student withdrew
Academic factor: Time from institutional enrollment to first enrollment in college algebra	Interval	0 semesters to 10 semesters* *Semesters includes fall, spring, and summer
Academic factor: Enrollment status	Dichotomous	Full-time or Part-time
Academic factor: Areas requiring remediation	Ordinal	None, one, two, or three
Academic factor: High school GPA	Interval	0.0* — 4.0 *Students who enter with a GED or other high school equivalency. All GPAs are collapsed into five categories (0.0, 1.0, 2.0, 3.0, and 4.0)
Demographic factor: COMPASS or ACT score	Interval	Pre-Algebra 0-100 Algebra 0-100 College Algebra 0-100 ACT below a 19
Demographic factor: Age	Interval	16-90
Demographic factor: Race	Dichotomous	Caucasian or African-American
Demographic factor: Gender	Dichotomous	Male or Female
Demographic factor: Financial-aid recipient	Dichotomous	Yes or No
Institutional factor: Faculty credentials	Nominal	Bachelor’s, Master’s, or Ph.D.
Institutional factor: Faculty employment status	Dichotomous	Full-time or Adjunct
Academic factor for second model: Performance in developmental math	Ordinal	A, B, C, D, F, or W* * Student withdrew

Protection from Harm

The data for this study were from previous semesters and did not include any identifying student information; therefore, there were no risks to the participants. However, all precautions were taken to protect the identity of the students involved in the study. While the data contained identifying student information, the data could only be accessed on a non-networked computer housed on BCC's campus. This study was approved by the Louisiana State University Institutional Review Board (E9742). The approved Institutional Review Board application is located in Appendix A.

CHAPTER 4: ANALYSIS AND RESULTS

The original sample was extracted from the BCC student management system (Banner). Reports were run using the Cognos system within Banner to identify all students who completed Math 0084 during the fall semester of 2013 and the fall semester of 2014. Another report was run to obtain all students who completed Math 1000 during the spring semester of 2015. After collecting the Cognos reports, additional data were obtained from the Financial Aid Office regarding students who received financial aid during the fall 2013, fall 2014, and spring 2015 semesters. Once all of the data were obtained, each semester's data was combined with financial aid data to create a complete data set.

After the initial data collection, each data set was analyzed to determine if any cases needed to be removed, based on the requirements of the study. The requirements for cases to be included were based on previous research that suggested a student's placement score was a predictor of student success in developmental math. The fall 2013 data set initially contained 311 cases. Many of these students arrived in Math 0084 without taking a placement test (COMPASS or ACT), these students either had previous placement decisions from other institutions or self-selected to enroll in developmental math. This data set contained more cases with an ACT math test scores than COMPASS test scores, so cases missing ACT math scores were removed. In the fall 2013 data set, 182 cases were removed due to missing test score values. Additionally, eight cases were removed because the race was neither black nor white, which were the only races included due to the extremely low numbers of other races represented in the sample. After removing all of the cases that did not meet the study requirements, 121 cases remained. The remaining 121 cases included students who had an ACT placement score and represented both races and genders. Although only 121 cases remained, these cases represented the overall population of BCC.

The fall 2014 data set initially contained 107 cases; 39 cases were removed due to missing ACT Math Test Score values and four cases were removed because the race was neither black nor white, leaving 64 cases in the data set. The spring 2015 data set contained 180 cases; 17 cases were removed because the race was neither black nor white, leaving 163 cases remaining in the data set. As with the fall 2013 data set, the remaining sample was representative of the overall population of BCC. After modifying the data in each data set, the data sets were imported into SPSS version 23 for analysis.

Participant Characteristics

The following independent variables were coded as dichotomous: race (Black=1 and White=0), gender (Female=1 and Male=0), instructor credentials (master's degree in math=1 and master's degree not in math=0), instructor status (full-time instructor=1 and part-time instructor=0), enrollment status (full-time student=1 and part-time student=0), and financial aid recipient (student receives financial aid=1 and student does not receive financial aid=0). All of the data for each data set were transformed to match the above definitions.

The following independent variables were coded as interval variables: age, high school GPA, overall BCC GPA, time from initial enrollment in BCC to the first enrollment in a math course (time at BCC), and areas requiring developmental education. Age represents the age of the student during the semester of the study. The high school GPA and overall BCC GPA were collapsed into whole numbers by removing the decimal portion of the GPA. If a student had a high school GPA of 2.40, the data were transformed to the whole number two (2) by dropping the decimal portion. The GPA was transformed to a whole number to facilitate analysis, since each student in the sample had a different GPA. There may have been only one student with a 2.410 GPA, which limited the ability to draw conclusions about the impact of the GPA. The time at BCC indicates the number of semesters a student was enrolled at BCC before enrolling in a math course. The areas requiring developmental education describes the number of areas in which a student was required to take developmental education courses. BCC offers developmental education in three areas, reading, English, and math. The variable was coded with values of zero (0) representing no developmental education courses required, one (1) representing one area required developmental education courses, two (2) representing two areas required developmental education courses, and three (3) representing three areas required developmental education courses. The following describes the participants for each data set.

Fall 2013

This data set contained 121 students. Of this number, 69 (57%) were black students and 52 (43%) were white students. These data were consistent with the overall population of BCC. The gender breakdown shows that there were more female students, 74 (61.2%), than male students, 47 (38.8%). Each instructor at BCC must possess a master's degree, but that degree does not have to be in math to teach a developmental math course. This data set had 47 (38.8%) instructors with a master's degree in math and 74 (61.2%) instructors with a master's degree in something other than math. There were 102 (84.3%) students in the sample who were taught by full-time instructors, while 19 (15.7%) students in the sample were taught by part-time instructors. The student's enrollment status included only 9 (7.4%) full-time students, while the remaining 112 (92.6%) were part-time students attending college less than 12 hours a semester. Finally, only 8 (6.6%) students received financial aid, while 113 (93.4%) students did not receive financial assistance to pay for school. Table 4 contains all of the information for the dichotomous variables in the fall 2013 data set.

This sample had a mean age of 20.71, with a standard deviation of 2.525. The youngest student was 18 and the oldest was 34 years old. The students in this sample had a high school GPA mean of 2.18, with a standard deviation of 0.775 and an overall BCC GPA mean of 1.91, with a standard deviation of 1.271. The students in this sample spent about one semester at BCC before enrolling in their first math course. Students in this data set had approximately two areas requiring developmental education courses. The information on ACT and COMPASS test scores is listed in Table 5.

Table 4
Fall 2013 Participant Characteristics for Dichotomous Variables (*N* =121)

Race	N	Percent
Black	69	57.0
White	52	43.0
Gender		
Female	74	61.2
Male	47	38.8
Instructor Status		
Full-time Instructor	102	84.3
Part-time Instructor	19	15.7
Instructor Credentials		
Master's Degree in Math	47	38.8
Master's Degree not in Math	74	61.2
Full-time Student Status		
Full-time Student	9	7.4
Part-time Student	112	92.6
Financial Aid Recipient		
Financial Aid Recipient	8	6.6
Not a Financial Aid Recipient	113	93.4

Table 5
Fall 2013 Participant Characteristics for Interval Variables (*N* =121)

Variable	Number	Range	Mean	SD
Age	121	18-34	20.71	2.525
High School GPA	121	0-4	2.18	0.775
Cumulative Overall GPA	121	0-4	1.91	1.271
ACT Math Test Score	121	13-26	17.23	2.469

(Table 5 continued)

Variable	Number	Range	Mean	SD
COMPASS Algebra Test Score	26	15-58	33.85	12.132
COMPASS Pre-Algebra Test Score	10	25-78	46.20	20.049
Number of Semesters at BCC	121	1-4	1.31	0.705
Areas Needing Remediation	121	1-3	1.99	0.811

Fall 2014

This data set contained 64 students. Of this number, 28 (43.8%) were black students and 36 (56.3%) were white students, which is not consistent with the overall population at BCC. There were 34 (53.1%) female students and 30 (46.9%) male students. The instructor credentials included 47 (75.8%) instructors with a master's degree in math and 15 (24.2%) instructors with a master's degree in something other than math. There were 47 (75.8%) students in the sample who were taught by full-time instructors, while 15 (24.2%) students were taught by part-time instructors. In terms of enrollment status, 28 (45.2%) were full-time students, while the remaining 34 (54.8%) were part-time students attending college less than 12 hours a semester. Finally, 41 (66.1%) students received financial aid, while 21 (33.9%) students did not receive financial assistance to pay for school. Table 6 contains information for all of the dichotomous variables for the fall 2014 data set.

This sample had a mean age of 26.41, with a standard deviation of 7.483. The youngest student was 18 and the oldest was 51 years old. The students in this sample had a high school GPA mean of 1.31, with a standard deviation of 1.067 and an overall BCC GPA mean of 2.22, with a standard deviation of 0.967. The fall 2014 data set contained students who were older and had a higher overall BCC GPA than the fall 2013 data set. The students in this sample spent almost two semesters at BCC before enrolling in their first math course. The students in this data set had almost two areas requiring developmental education courses. The information on ACT and COMPASS test scores is listed in Table 7. The descriptive statistics for all of the study variables in the fall 2014 data set are listed in Tables 6 and 7.

Table 6
Fall 2014 Participant Characteristics for Dichotomous Variables (*N* = 64)

Characteristic	N	Percent
Race		
Black	28	43.8
White	36	56.3
Gender		
Female	34	53.1
Male	30	46.9
Instructor Status		
Full-time Instructor	47	75.8
Part-time Instructor	15	24.2
Instructor Credentials		
Master's Degree in Math	47	75.8
Master's Degree not in Math	15	24.2
Full-time Student Status		
Full-time Student	28	45.2
Part-time Student	34	54.8
Financial Aid Recipient		
Financial Aid Recipient	41	66.1
Not a Financial Aid Recipient	21	33.9

Table 7
Fall 2014 Participant Characteristics for Interval Variables (*N* = 64)

Variables	Number	Range	Mean	SD
Age	64	18-51	26.41	7.483
High School GPA	64	0-4	1.31	1.067
Cumulative Overall GPA	64	0-4	2.22	0.967
ACT Math Test Score	23	14-20	16.78	1.380
COMPASS Algebra Test Score	64	15-71	31.75	13.488
COMPASS Pre-Algebra Test Score	41	20-82	44.76	18.976
Number of Semesters at BCC	64	1-5	2.27	1.144
Areas of Remediation	64	0-3	1.80	0.820

Spring 2015

This data set contained 163 students. Of these, 57 (35%) were black students and 106 (65%) were white students. Traditionally, BCC serves more black students than white students, so this sample was not consistent with the overall population. There were 98 (60.1%) female students and 65 (39.9%) male students. All of the instructors in this sample had a master's degree in math and were full-time instructors. The student enrollment was 89 (54.6%) full-time students, with the remaining 74 (45.4%) being part-time students attending college less than 12 hours a semester. Finally, 89 (54.6%) students received financial aid, while 74 (45.4%) students did not receive financial assistance to pay for school. The final independent variable of the final course grade in Math 0084 was coded as an interval variable, where the course grades were transformed into the following: A is 4, B is 3, C is 2, D is 1, and F is 0. Information on the number and percent of Math 0084 final course grades is found in Table 8.

This sample had a mean age of 25.27, with a standard deviation of 7.755. The youngest student was 17 and the oldest was 52 years old. The students in this sample had a high school GPA mean of 1.91, with a standard deviation of 1.286 and an overall BCC GPA mean of 2.56 with a standard deviation of 0.851. The students in this sample spent almost three semesters at BCC before enrolling in college algebra (Math 1000). The information on ACT and COMPASS test scores is listed in Table 9. The descriptive statistics for all of the study variables in the spring 2015 data set are listed in Tables 8 and 9.

Table 8
Spring 2015 Participant Characteristics for Dichotomous Variables (*N* = 163)

Variable	N	Percent
Race		
Black	57	35.0
White	106	65.0
Gender		
Female	98	60.1
Male	65	39.9
Instructor Status		
Full-time Instructor	163	100.0
Part-time Instructor	0	0.0
Instructor Credentials		
Master's Degree in Math	163	100.0

(Table 8 continued)

Master's Degree not in Math	0	0.0
Full-time Student Status		
Full-time Student	89	54.6
Part-time Student	74	45.4
Financial Aid Recipient		
Financial Aid Recipient	89	54.6
Not a Financial Aid Recipient	74	45.4
Letter Grade in Math 0084		
A	17	20.7
B	21	25.6
C	18	22.0
D	11	13.4
F	15	18.3

Table 9

Spring 2015 Participant Characteristics for Interval Variables (*N* = 163)

Variables	Number	Range	Mean	SD
Age	163	17-52	25.27	7.755
High School GPA	163	0-4	1.91	1.286
Cumulative Overall GPA	163	0-4	2.56	0.851
ACT Math Test Score	55	14-27	20.15	2.690
COMPASS Algebra Test Score	40	2-71	34.12	15.872
COMPASS Pre-Algebra Test Score	22	23-81	50.27	21.920
Number of Semesters at BCC	163	1-7	2.87	1.419

Ordinal Regression Analysis

Research Question One: What are the predictors of success in developmental math?

Fall 2013

The dependent variable for this analysis was final course grade in Math 0084. After retrieving data from the Cognos system and combining that data with the financial aid data and removing cases that did not meet the study criteria, 121 cases remained in the fall 2013 data set for analysis. Before creating the model, an analysis of correlation coefficients was conducted to determine the significance of each of the study predictors. Based on the results, the majority of the initial predictors were not statistically significant enough to be included in the final model.

Table 10 includes all of the correlation coefficients for predictors of student success in Math 0084.

Table 10
Fall 2013 Kendal Correlation Coefficient and Significance for Predictors of Student Success in Math 0084 (*N*=121)

Predictor of Student Success	Correlation Coefficient with Math 0084	Significance
Student Race	-0.126	0.123
Student Gender	-0.004	0.959
Student Age *	-0.211	0.004
Number of Semesters at BCC	0.121	0.129
Instructor Status	-0.044	0.589
Instructor Credentials *	-0.485	0.000
HS GPA*	0.300	0.000
Cumulative Overall GPA at BCC [A]	0.875	0.000
Full-Time Student Status	-0.037	0.649
Financial Aid Recipient	0.035	0.673
Areas Needing Remediation *	-0.290	0.000
ACT Math Score [B]	0.351	0.000
COMPASS Algebra Test Score	0.270	0.078
COMPASS Pre-Algebra Test Score	0.130	0.628

* Predictors included in the final statistical model.
[A] This predictor was not included because it contains the final grade for Math 0084. The inclusion of the final course grade will interfere with the statistical analysis.
[B] This predictor was not included due to a small number of cases that included an ACT math score.

After the significant predictors were identified, the assumptions for ordinal regression were tested. The first assumption was that the data set had an ordinal variable as the dependent variable. This study used the course final grade as the dependent variable, which was coded as an ordinal variable. The second assumption was that the independent variables were either continuous, ordinal, or nominal. All of the independent variables for this study were not continuous, nominal, or ordinal; four variables were scale. As a result, this data did not meet the second assumption. The third assumption was that no multicollinearity existed between the independent variables. To test for multicollinearity, the tolerance value, which represented the percent of variance that could be attributed to the other predictors, should be larger than 0.10 if there was no multicollinearity. Additionally, the Variance Inflation Factor (VIF) showed coefficients that were less than 10, which indicated that there was no multicollinearity. Table 11 contains the results of the fall 2013 multicollinearity test. The final assumption was that the independent variables have proportional odds. The test for parallel lines indicated that the assumption of proportional odds must be rejected since the general model had a significance level of $p<0.05$. This assumption was tested using SPSS version 23, and the results are listed in Table 12. The data for fall 2013 did not meet the assumptions of ordinal regression, so a multinomial regression was conducted.

Table 11
Fall 2013 Coefficients to Test for Multicollinearity (*N*=121)

Variable	Collinearity Statistics	
	Tolerance	VIF
Areas Needing Remediation	0.896	1.116
HS GPA	0.794	1.260
Student Age	0.738	1.354
Instructor Credentials	0.748	1.337

Table 12
Fall 2013 Test of Parallel Lines [a]

Model	-2 Log Likelihood	Chi-Square	df	Significance
Null Hypothesis	219.613			
General	180.099 [b]	39.514 [c]	12	0.000

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a Link function: Logit
b The log-likelihood value cannot be further increased after maximum number of step-halving.
c The Chi-Square statistic is computer based on the log-likelihood value of the last iteration of the general model. Validity of the test is uncertain.

In order to conduct a multinomial regression, the assumptions must be tested prior to analysis. The first two assumptions were similar to the assumptions of ordinal regression. The dependent variable should be nominal, but could be ordinal, as in this case. The independent variables must be continuous or nominal, which all independent variables in this study were. The third assumption was that the variables are mutually exclusive with exhaustive categories, and this assumption was met. The fourth, fifth, and six assumptions were tested using SPSS. Table 11 contains the information about multicollinearity. The fifth assumption was determining if there is a linear relationship. This data set contained a linear relationship. The final assumption was that there are no outliers, which was true for this data set. The fall 2013 data set met all of the assumptions for multinomial regression.

The process to create a statistical model included adding and removing predictors until a model was created that included the best predictors of student success. The best model revealed that student age, instructor credentials, areas requiring remediation, and HS GPA were the most statistically significant predictors of student success in Math 0084. A student's HS GPA ($p < 0.05$) and the number of areas requiring remediation ($p < 0.05$) were predictors of student success for all final grades in Math 0084. A student's age was statistically significant ($p < 0.05$) for only final Math 0084 grades of "C" or below. A student's age was not a statistically significant predictor of student success in Math 0084 when the student achieved a final grade of "B" or higher. An instructor's credentials were only significant ($p < 0.05$) for grades of "D" and "F" in Math 0084.

The B values represented how the odds of a student who received a grade in Math 0084 would change, based on one of the predictor values changing. For example, if a student received an "F" and the HS GPA increased one point (from a 1.0 to a 2.0), the odds of that student receiving an "F" over an "A" would decrease 2.625 units. The Exp(B) values represented the likelihood of one of the predictors to determine the final course grade in Math 0084. For example, if a student required remediation in all areas (three areas), the likelihood he/she would receive an "F" increased by 12.865 units. Tables 13 and 14 contain the results of the multinomial regression that was run on the fall 2013 data set.

Table 13
Fall 2013 Multinomial Regression Results (*N* = 121)

Grade	Predictor	B	Std. Error	Wald	df	Sig	Exp(B)
F	Intercept	37.425	11.210	11.145	1	0.001	-
	Areas of Remediation	2.554	0.893	8.178	1	0.004	12.865
	HS GPA	-2.625	1.013	6.708	1	0.010	0.072
	Age	-1.504	0.459	10.761	1	0.001	0.222
	Instructor Credentials	-7.119	1.871	14.478	1	0.000	0.001
D	Intercept	15.603	7.386	4.463	1	0.035	-
	Areas of Remediation	2.549	0.839	9.232	1	0.002	12.789
	HS GPA	-2.193	0.976	5.045	1	0.025	0.112
	Age	-0.548	0.235	5.438	1	0.020	0.578
	Instructor Credentials	-3.273	1.567	4.365	1	0.037	0.038
C	Intercept	19.498	7.355	7.028	1	0.008	-
	Areas of Remediation	1.638	0.793	4.266	1	0.039	5.145
	HS GPA	-2.719	0.931	8.536	1	0.003	0.066
	Age	-0.632	0.243	6.776	1	0.009	0.532
	Instructor Credentials	-1.412	1.539	0.842	1	0.359	0.244
B	Intercept	10.986	6.634	2.742	1	0.098	-
	Areas of Remediation	2.169	0.793	7.486	1	0.006	8.750
	HS GPA	-2.470	0.934	6.995	1	0.008	0.085
	Age	-0.326	0.190	2.958	1	0.085	0.722
	Instructor Credentials	-0.464	1.493	0.097	1	0.756	0.629

Note: The Reference Category is a grade of A.

Table 14
Fall 2013 Pseudo R-Square

Cox and Snell	0.613
Nagelkerke	0.640
McFadden	0.300

Fall 2014

The dependent variable for this analysis was final course grade in Math 0084. After retrieving data from the Cognos system and combining that data with the financial aid data and removing cases that did not meet the study criteria, 64 cases remained in the fall 2014 data set for analysis. Based on the model created for the fall 2013 data set, the same predictors were included in the model to attempt to verify the model. Table 15 includes all of the correlation coefficients for predictors of student success in Math 0084.

Table 15
Fall 2014 Kendal Correlation Coefficient for Predictors of Student Success in Math 0084 (*N*=64)

Predictor of Student Success	Correlation Coefficient with Math 0084	Significance
Student Race	-0.082	0.477
Student Gender [A]	0.417	0.000
Student Age *	0.116	0.235
Number of Semesters at BCC	-0.131	0.218
Instructor Status	0.021	0.859
Instructor Credentials *	0.021	0.859
HS GPA*	-0.079	0.471
Cumulative Overall GPA at BCC [B]	0.619	0.000
Full-Time Student Status	0.051	0.658
Financial Aid Recipient	0.186	0.106
Areas Needing Remediation *	-0.092	0.397
ACT Math Score	0.067	0.713
COMPASS Algebra Test Score	0.015	0.873
COMPASS Pre-Algebra Test Score	0.091	0.450

* Predictors included in the final statistical model.
[A] This predictor was not included because it was not a statistically significant predictor in the fall 2013 model.
[B] This predictor was not included because it contains the final grade for Math 0084. The inclusion of the final course grade will interfere with the statistical analysis.

Next, the assumptions for ordinal regression were tested. The first assumption was that the data set had an ordinal variable as the dependent variable. This study used the course final grade as the dependent variable that was coded as an ordinal variable. The second assumption was that the independent variables were either ordinal or nominal. All of the independent variables for this study are nominal, so the first two assumptions of ordinal regression were met. The third assumption was that no multicollinearity exists between the independent variables. To test for multicollinearity, the tolerance value, which represents the percent of variance that cannot be attributed to the other predictors, should be larger than 0.10 if there is no multicollinearity. Additionally, the Variance Inflation Factor (VIF) shows coefficients that are less than 10, which indicates that there was no multicollinearity. Table 16 contains the results of the fall 2014 multicollinearity test. The final assumption was that the independent variables had proportional odds. This assumption was tested using SPSS version 23, and the results are listed in Table 17. The data for fall 2014 did meet the assumption of proportional odds, since the p value was larger than 0.05. However, since the fall 2013 data were analyzed using multinomial regression, the fall 2014 data were analyzed using multinomial regression.

Table 16
Fall 2014 Coefficients to Test for Multicollinearity (*N*=64)

Variable	Collinearity Statistics	
	Tolerance	VIF
Areas Needing Remediation	0.913	1.095
HS GPA	0.680	1.470
Student Age	0.653	1.530
Instructor Credentials	0.896	1.116

Table 17
Fall 2014 Test of Parallel Lines [a]

Model	-2 Log Likelihood	Chi-Square	df	Significance
Null Hypothesis	168.030			
General	157.064 [b]	10.966 [c]	12	0.532

The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a Link function: Logit
b The log-likelihood value cannot be further increased after maximum number of step-halving.
c The Chi-Square statistic is computer based on the log-likelihood value of the last iteration of the general model. Validity of the test is uncertain.

In order to conduct a multinomial regression, the assumptions must be tested prior to analysis. The first two assumptions were similar to the assumptions of ordinal regression. The dependent variable should be nominal, but can be ordinal as in this case. The independent variables must be continuous or nominal, which all independent variables in this study were. The third assumption was that the variables were mutually exclusive with exhaustive categories, and this assumption was met. The fourth, fifth, and six assumptions were tested using SPSS. Table 16 contains the information about multicollinearity. The fifth assumption was determining if there is a linear relationship; this data set contained a linear relationship. The final assumption was that there are no outliers, which was true for this data set. The fall 2014 data set met all of the assumptions for multinomial regression.

The fall 2013 model revealed that student age, instructor credentials, areas requiring remediation, and HS GPA were the most statistically significant predictors of student success in Math 0084. The fall 2014 data set was utilized to validate the fall 2013 data set. However, the predictors that were statistically significant for the fall 2013 data set were not significant in the fall 2014 data set. The results of the multinomial regression are listed in Tables 18 and 19. Due to the data in the fall 2014 data set not matching the fall 2013 data set, the author was unable to validate the model created in the fall 2013 data set.

Table 18
Fall 2014 Multinomial Regression Results (*N* = 64)

Grade	Predictor	B	Std. Error	Wald	df	Sig	Exp(B)
F	Areas of Remediation	1.265	0.829	2.326	1	0.127	3.543
	High School GPA	-0.542	0.625	0.752	1	0.386	0.581
	Age	-0.182	0.134	1.836	1	0.175	0.834

(Table 18 continued)

Grade	Predictor	B	Std. Error	Wald	df	Sig	Exp(B)
F	Instructor Credentials	0.768	1.402	0.300	1	0.584	2.155
D							
	Areas of Remediation	-0.676	0.624	1.171	1	0.279	0.509
	High School GPA	0.087	0.477	0.033	1	0.856	1.091
	Age	-0.199	0.119	2.785	1	0.095	0.819
	Instructor Credentials	0.816	1.056	0.597	1	0.440	2.261
C							
	Areas of Remediation	0.435	0.500	0.758	1	0.384	1.545
	High School GPA	0.008	0.476	0.000	1	0.986	1.008
	Age	0.012	0.065	0.035	1	0.851	1.012
	Instructor Credentials	-0.174	1.036	0.028	1	0.867	0.841
B	Areas of Remediation	-0.031	0.444	0.005	1	0.944	0.969
	High School GPA	-0.237	0.389	0.370	1	0.543	0.789
	Age	-0.034	0.054	0.404	1	0.525	0.966
	Instructor Credentials	0.356	0.820	0.189	1	0.664	1.428
A*							

* The Reference Category is A

Table 19
Fall 2014 Pseudo R-Square

Cox and Snell	0.216
Nagelkerke	0.227
McFadden	0.081

Research Question Two: Does success in a developmental math course predict success in college algebra?

The dependent variable for this analysis was final course grade in Math 1000. After retrieving data from the Cognos system and combining that data with the financial aid data and removing cases that did not meet the study criteria, 163 cases remained in the spring 2015 data set for analysis. To answer the second research question, the study criteria had to be revised to include the final course grade in Math 0084. A student's placement decision is based on the student either completing Math 0084, taking the ACT or COMPASS placement test, or having previous placement data from another institution.

The independent variable was the placement decision. Table 20 shows the distribution of final course grades for Math 1000, based on the placement decision.

Table 20
Distribution of Final Course Grades in Math 1000 Based on Placement Information (*N*=163)

Placement Decision	Math 1000 Final Course Grade					Total Number
	F	D	C	B	A	
ACT	13	1	12	12	4	42
COMPASS	1	0	0	2	0	3
Math 0084	16	11	19	23	18	87
Previous Placement	9	1	7	7	7	31

Based on Table 20, 87 students completed developmental math prior to taking Math 1000. Those students who completed Math 0084 had 68.9% passing rate for Math 1000. Seventy-six students did not take developmental math prior to enrolling in Math 1000. These students either placed directly into Math 1000 or had previous placement from other institutions. Students who directly enrolled in Math 1000 had a 67.1% passing rate.

This study utilized chi-square test of independence for placement decision and final course grade in Math 1000 to gain a deeper understanding of the impact developmental math has on a student's success in college algebra. The analysis revealed that students who successfully completed developmental math were more likely to be successful in college algebra than students who entered college algebra through other avenues.

CHAPTER 5: DISCUSSION

The purpose of this research study was to assess the effectiveness of developmental math and the predictors of student success in developmental math. After analyzing the predictors derived from the literature, this study determined that the best predictors of student success in developmental math were a student's age, high school GPA, number of areas that require remediation, and the instructor's credentials. Following the analysis of the predictors of success in developmental math, an analysis of the effectiveness of developmental math was conducted. This chapter summarizes the results for each research question. The results are discussed, based on the framework of the reviewed literature. Implications for future research into developmental math are provided. Finally, the limitations of the study and how the study added to the larger body of knowledge on developmental math are discussed.

The Predictors of Success in Developmental Math

Initially, the existing literature indicated that several factors contributed to a student's success in developmental math. Factors such as gender, race, placement test score (COMPASS or ACT), enrollment status, delayed enrollment in developmental courses, and financial aid utilization were indicated as predictors of student success. However, this study revealed that the most effective predictors of student success in developmental math were a student's age, high school GPA, number of areas requiring remediation, and instructor credentials.

Although this study did not find that placement scores were a significant predictor of student success, this study was able to confirm the work of Roksa et al. (2009). According to Roksa et al. (2009), when controlling for individual characteristics and attending institution, a student's reading and writing placement test scores did not predict whether students would pass the first college-level English course (Roksa et al., 2009). This study supported the assertion that placement scores were not a significant predictor (COMPASS Pre-Algebra and Algebra had a p>0.05) of student success. Although ACT Math score had a p<0.05 this analysis did not include enough cases to provide valid results (see Table 10).

Crisp and Delgado (2014) identified academic preparation and high school experiences as factors that influence a student's success (Crisp & Delgado, 2014). This study also found a student's high school GPA was an important predictor of success in developmental math. According to Table 21, students who had at least a 2.0 high school GPA were more likely to earn a passing grade in Math 0084 than those who had a high school GPA under 2.0. This means that students who were more academically prepared when they enrolled in a community college were more likely to successfully complete the developmental courses they were required to take. In practice, community colleges should focus resources on students who arrive less academically prepared, in order to improve the chances that those students will succeed.

Table 21
Fall 2013 Cross Tabulation of Final Grade in Math 0084 vs. High School GPA (*N* = 1221)

Final Grade	High School GPA					Total
	0.0	1.0	2.0	3.0	4.0	
F	2	1	20	2	0	25
D	0	1	15	4	0	20
C	1	2	17	9	0	29
B	4	0	15	13	0	31
A	0	1	3	11	1	16
Total	7	5	69	39	1	121

Previous research conducted by Calcagno et al. (2008) indicated that instructors holding a master's degree or higher had a positive impact on student performance in developmental education courses (Calcagno et al, 2008). Although all of the instructors in this study held master's degrees, the difference in degrees in math versus non-math was significant for students earning a non-passing grade. According to Table 22, more students who received a non-passing grade were taught by instructors holding a master's degree in math. Although this sounds counterintuitive, the ability to explain difficult math concepts to students who are lacking math skills may be easier for instructors who are not “math” teachers. From the author’s personal experience, this is apparent in real classrooms with real students.

Table 22
Fall 2013 Cross Tabulation of Final Grade in Math 0084 vs. Instructor Credentials (*N* = 121)

Final Grade	Instructor Credentials		Total
	Master’s Degree in Math	Master’s Degree in Non-Math	
F	23	2	25
D	11	9	20
C	5	24	29
B	5	26	31
A	3	13	16
Total	47	74	121

Despite the inability to confirm the model created by the fall 2013 data, the fall 2014 data contained some interesting results. Unlike the fall 2013 data, the fall 2014 data did not support the assertion that instructors with master’s degrees in non-math areas were better able to prepare students for success. According to Table 23, instructors with master’s degrees in math were better able to prepare students for success. Even though instructors with non-math master’s degrees had fewer students earn non-passing grades, more students received passing grades from instructors with master’s degrees in math. These results may not be completely accurate since three times as many students were taught by instructors with math master’s degrees than with non-math master’s degrees.

Table 23
Fall 2014 Cross Tabulations for Final Math 0084 Grade vs. Instructor Credentials (*N* = 62)

Final Grade	Instructor Credentials		Total
	Master’s Degree in Math	Master’s Degree in Non-Math	
F	4	1	5
D	6	3	9
C	9	2	11
B	14	5	19
A	14	4	18
Total	47	15	62

The number of areas that require remediation is often linked to students not succeeding. Fong et al., Bahr, and Hoyt reported the number of developmental courses a student is required to take is a predictor of student success (Fong et al., 2015; Bahr, 2010; Hoyt, 1999). If a student required remediation in multiple areas, there was a high probability that the student would drop out before completing a degree program. Many studies have documented the link between the amount of developmental coursework students were required to complete and the likelihood of dropout (Bahr, 2010; Hoyt, 1999). According to Table 24, if a student required remediation in all three areas (reading, English, and math), he or she was more likely to receive a non-passing grade in Math 0084. However, as the number of areas decreased, the likelihood of receiving a passing grade increased. Although this study was not able to determine dropout rates, the work by Bahr and Hoyt, in combination with this study, showed that a student who required numerous developmental education courses was not likely to be successful. This research study supported these findings by showing that students assigned multiple areas of remediation were less likely to succeed in their developmental math courses. Table 24 contains the fall 2013 information regarding the passage rates for Math 0084, based on the number of areas requiring remediation. The fall 2014 data revealed that students requiring three areas of remediation were less likely to succeed in Math 0084 than students only requiring one area of remediation. The results of the fall 2014 analysis are listed in Table 25.

Table 24
Fall 2013 Cross Tabulation of Final Grade in Math 0084 vs. Areas Requiring Remediation (N = 121)

Final Grade	Areas Requiring Remediation			Total
	One Area of Remediation	Two Areas of Remediation	Three Areas of Remediation	
F	2	13	10	25
D	4	6	10	20
C	12	10	7	29
B	8	11	12	31

(Table 24 continued)

Final Grade	Areas Requiring Remediation			Total
	One Area of Remediation	Two Areas of Remediation	Three Areas of Remediation	
A	14	2	0	16
Total	40	42	39	121

Table 25
Fall 2014 Cross Tabulation for Final Math 0084 Grade vs. Areas Requiring Remediation (*N* = 63)

Final Grade	Areas Requiring Remediation				Total
	No Areas of Remediation	One Area of Remediation	Two Areas of Remediation	Three Areas of Remediation	
F	0	0	3	2	5
D	1*	4	3	1	9
C	0	4	3	4	11
B	0	9	8	3	20
A	0	9	5	4	18
Total	1	26	22	14	63

* This student self-selected to enroll in developmental Math 0084.

Although previous research indicated the impact that a student's prior academic experience had on his or her success in developmental math, the fall 2014 data set showed something interesting. When recording the values for the HS GPA variable, any student who did not enter BCC with a high school diploma received a HS GPA of zero. Students who entered with a GED or took the Ability to Benefit Test and, therefore, did not have a high school GPA to enter into the system were given a 0.0 GPA. The fall 2014 data set revealed that students with a 0.0 HS GPA actually did fairly well in Math 0084. This could be due to the fact that these students are different in many ways from traditional high school graduates. These students could be older or more persistent. Unfortunately, the data for this study was not designed to show the differences between students who earned a zero high school GPA and those who earned a GED and, therefore, were given a 0.0 HS GPA. According to Table 26, students who had a HS GPA of 0.0 passed Math 0084 at a 91.3% passage rate, as compared to students who earned a 2.0 or higher GPA with a passage rate of 72.2%. Although these students appear to have lower academic preparedness on paper, the reality is that these students were able to successfully complete Math 0084 at a higher rate than those who appeared to be better academically prepared.

Table 26
Fall 2014 Cross Tabulation for Final Math 0084 Grade vs. High School GPA (*N* = 63)

Final Grade	High School GPA					Total
	0.0	1.0	2.0	3.0	4.0	
F	1	1	3	0	0	5
D	1	1	7	0	0	9
C	4	0	7	0	0	11
B	8	2	9	1	0	20
A	9	0	5	4	0	18
Total	23	4	31	5	0	63

Although the fall 2014 data set did not support all of the conclusions drawn from the fall 2013 data set regarding the impact of a student's high school GPA, there is support for the number of areas requiring remediation. Students who required more than one area of remediation were less successful in Math 0084 than students who only required remediation in one area. According to Table 25, students who only required remediation in one area had a passage rate of 84.6%, while those requiring two or three areas of remediation had passage rates of 72.7% and 78.5% (respectively).

The Effectiveness of Developmental Math in Predicting Success in College Algebra

Initially, the study was designed to utilize regression discontinuity (RD) in order to capture the effectiveness of placement scores in determining remediation that would show how effective Math 0084 was in preparing students for success in Math 1000. However, after the data set was completed, utilizing RD was not an option due to the lack of placement data for all of the students in the sample. Instead, an analysis was run to determine the impact Math 0084 had on a student's success in Math 1000. Although there was no significance between the Math 0084 final course grade and the Math 1000 final course grade ($p > 0.05$), more students passed Math 1000 after taking Math 0084 versus students who entered Math 1000 in other ways. Students who took

Math 0084 prior to enrolling in Math 1000 had a 68.9% passage rate, compared to students who did not take Math 0084 and had a 58.6% passage rate. This is contrary to existing literature that documents the negative effect remedial education had on success in the first college-level course. Roksa et al. (2009) found that only 48 percent of students passed the first college-level math course after taking developmental math (Roksa et al., 2009).

Limitations of the Study

The biggest limitation of this study is the sample size. Due to the small average enrollment at BCC, a small pool of students met the study criteria. Since there was a small sample size, the results are not easily generalized. In addition to a small sample size, this study was conducted on a one-campus community college and that can also limit the generalization of the results. Finally, the missing placement data limited the researcher's ability to explore the impact placement had on a student's success.

The small sample size was an issue when trying to generalize the results obtained to the larger population of community college students taking developmental math courses. Although this study determined that a student's age, high school GPA, areas requiring remediation, and the instructor's credentials were predictors of student success in Math 0084, these factors might not be significant when analyzing larger sets of data. The small sample size could have been the reason the fall 2014 data set was unable to validate the model created by the fall 2013 data.

Since this study was conducted on a single campus, institutional policies and practices influence how data is recorded. This study experienced missing data for placement decisions that impacted the researcher's ability to fully analyze the factors that might predict a student's success. In addition to missing placement data, there were issues tracking students from developmental math to college-level math. Community college students often attempt developmental math courses several times before successfully completing the course. This study was not able to track the multiple attempts students may have had before successfully completing Math 0084. There was also difficulty tracking students from the successful completion of Math 0084 into Math 1000, since not all students were required to take Math 1000 nor were they required to take Math 1000 immediately following the successful completion of Math 0084.

Since this study was conducted at a community college, this could limit the generalization of the results because students who attend community colleges are generally less academically prepared than students at four-year institutions. According to data from the National Education Longitudinal Study of 1988 (NELS 88) and from the National Postsecondary Student Aid Study (NPSAS:04), approximately half of all community college students took at least one developmental education course, while almost 44 percent took more than one developmental education course (Horn, Nevill, & Griffith, 2006; NCES, 1988). This difference in the number of developmental courses students at community colleges took, versus the number of developmental courses students at four-year institutions took, made generalizing the results of this study difficult.

Implications for Future Research

Future research on the predictors of student success in developmental math could build on this study by finding a large data sample to test the model. The small sample size of this study limited the generalization of the results. Finding a larger data sample with complete data on placement decisions would allow researchers to create a more robust model to better predict the factors of student success.

Fully understanding the effectiveness of developmental math could be achieved by following students who successfully completed developmental math and observing their performance in the first college-level math course. To be successful, the research would have to cover a significant amount of time to ensure that the student's performance in the college-level math course was captured, no matter how many semesters had elapsed between successful completion of the developmental math course and enrollment in the first college-level math course. This study was unable to follow all students who took developmental math before taking a college-level math course due to students not enrolling in college-level math immediately after successfully completing developmental math. Unlike this study, future studies should ensure that data could be obtained on the same students in order to be able to follow progress through developmental math into college-level math.

Implications for Community Colleges

This research study has implications for community colleges trying to improve student success in developmental math courses. Based on the results of the fall 2013 analysis, institutions need to provide additional resources to students who have lower high school GPAs, since there is a strong correlation between academic preparedness and success in developmental math. Based on the results of the fall 2014 data set, institutions might want to record high school equivalency in a different way to provide a richer data set for analysis, as well as prevent students with a high school equivalency from being grouped with students who were academically unprepared in high school.

Not only should institutions focus resources on students who were academically unprepared in high school, but there should also be resources for students who were assigned multiple areas of remediation. If a student was assigned multiple areas of remediation, the likelihood is that the student would not complete a degree program. The ever-increasing demand for institutions to produce completers means institutions should focus resources where the biggest impact can be made on student success.

In addition, as institutions are making hiring decisions and teaching assignments, it is important to keep in mind that instructors who hold a master's degree in non-math were more likely to produce successful students. From a practical perspective, knowing the type of instructor who is more likely to produce successful students is a benefit for institutions facing increasing demands to have students successfully complete degree programs.

Although developmental math did not have a statistically significant impact on a student's success in the first college-level math course, there was a relationship between a student's success and the path taken to get to the first college-level math course. When institutions are making policies regarding developmental education, knowing that students who needed developmental math and took developmental math prior to taking the college-level math course were more successful could shape policies that require students to take the developmental math course(s) without exception.

Merits of the Current Study

Although there is existing research on the impact student demographic data (race, age, and gender) have in determining student success (Bettinger & Long, 2005; Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999; and Hoyt, 1999), very few studies are focused on the combination of demographic factors, academic readiness, and institutional factors (Fong, Melguizo, & Prather, 2015). This study combined an analysis of multiple factors, including student demographic factors, a student's academic readiness, and institutional factors, all of which are documented to impact a student's success. Although this study did not show the significance of many of the factors, that can be attributed to the sample size and the lack of a robust data set.

Many studies on developmental education have been conducted utilizing data from Achieving the Dream, such as the one conducted by Bailey et al. (2010). This study utilized data from Achieving the Dream that includes institutions that serve more minorities, are larger institutions, and have instructional costs that are less than other community colleges. Due to these differences, the results are hard to generalize to all community colleges (Bailey et al., 2010; Bremer, et al., 2013). Additionally, utilizing data from Achieving the Dream did not include individual predictors. Researchers utilizing Achieving the Dream data had to supplement the data with information from the Integrated Postsecondary Education Data System (IPEDS). The IPEDS data included institutional factors and information used as proxy for individual characteristics. Due to the utilization of indirect measures for individual characteristics, drawing conclusions about the impact of the individual characteristics was challenging (Bailey et al., 2010). This study, although small in sample size, was able to capture some individual characteristics directly.

The Boatman and Long (2010) study conducted in Tennessee, consisted of individual-level data for a period of three academic years and graduation data collected after six years (Boatman & Long, 2010). Although this study had a robust data set, the study was conducted at both two- and four-year institutions in the state, which means the data were more difficult to generalize regarding the effect of community college developmental education courses. Bettinger and Long (2009) conducted a study of first-time freshmen at all Ohio community colleges, but excluded all of Ohio's two-year technical colleges which made the results harder to generalize since most community college students, including technical students, require some form of remediation (Bettinger & Long, 2009). The current study did include students enrolled in academic and technical programs. Similar to the study conducted by Bettinger and Long (2009), this study was designed to not compare developmental students to non-developmental students, since better-prepared students were less likely to be assigned developmental coursework and more likely to have the skills to be more successful in college-level courses. By comparing only developmental students, there was a more-thorough analysis of the causal effects of developmental education (Bettinger & Long, 2009).

The current study is similar to the study conducted by Bremer et al. (2013) in that a single institution was examined. The Bremer et al. (2013) study involved several states, but only one institution in each state. The strength of this study was the ability to examine the data more thoroughly, since there was a richness of data available at a single institution that might not be available across a community college system or from multiple states (Bremer et al., 2013).

This study contributed to the literature base in several ways. This study identified predictors of student success in developmental math courses that were previously not analyzed together. Determining that student age, high school GPA, instructor credentials, and areas needing remediation were significant predictors of student success enriched the knowledge base of developmental math education. Additionally, this study illustrated that although there was no statistically significant connection between successfully completing a developmental math course and successfully completing the first college-level math course, students who took a developmental math course prior to the first college-level math course were more likely to earn a passing grade than students who enrolled directly in the college-level math course.

Conclusion

Developmental education is a complex endeavor, with developmental math being even more challenging for both students and institutions. Many students arrive at higher education institutions unprepared for the demands of college-level math due to a lack of skills. This author has heard many anecdotal stories from students stating how they wish they had paid more attention in high school because they never realized how important math is or that they would ever need it again. This, coupled with a fear of math many students have, makes succeeding in math a challenge. Institutions also face issues with students stopping out because they were unable to pass the required math courses. This research was able to point to predictors of student success in developmental math. This research indicated that students with lower academic performance in high school were more likely to not pass developmental math. Students who required remediation in more than one area were also more likely to not pass developmental math. Finally, knowing that students who were assigned a developmental math course and successfully completed that course were more likely to succeed in the first college-level math course could allow institutions to focus resources and interventions on students who have weaker academic skills, as illustrated by lower high school GPAs and requiring remediation in multiple areas.

Results from the current study should be interpreted with caution due to the small sample size. Future research could expand these findings by analyzing the created model with a larger sample size. Furthermore, institutions should use these results to guide the allocation of resources so that students in need of assistance could receive help to be successful, not only in developmental math, but in college as a whole.

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APPENDIX: INSTITUTIONAL REVIEW BOARD APPLICATION

ACTION ON EXEMPTION APPROVAL REQUEST

Institutional Review Board
Dr. Dennis Landin, Chair
130 David Boyd Hall
Baton Rouge, LA 70803
P: 225.578.8692
F: 225.578.5983
irb@lsu.edu | lsu.edu/irb

TO: Julia Sullivan
Higher Education

FROM: Dennis Landin
Chair, Institutional Review Board

DATE: February 2, 2016

RE: **IRB#** E9742

TITLE: Developmental Math Education, The Bermuda Triangle of Student Success, Many Enter but Few Succeed

New Protocol/Modification/Continuation: New Protocol

Review Date: 2/1/2016

Approved X **Disapproved**__________

Approval Date: 2/2/2016 **Approval Expiration Date:** 2/1/2019

Exemption Category/Paragraph: 1; 4a

Signed Consent Waived?: Yes

Re-review frequency: (three years unless otherwise stated)

LSU Proposal Number (if applicable):

Protocol Matches Scope of Work in Grant proposal: (if applicable)

By: Dennis Landin, Chairman ______________________________

PRINCIPAL INVESTIGATOR: PLEASE READ THE FOLLOWING –
Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

**All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/irb*

VITA

Julia Paxton Sullivan, a native of Baton Rouge, Louisiana, received her bachelor's degree from Louisiana State University in 1997. She then went on to complete her master's degree in 1998 as part of the Holmes Program at Louisiana State University. After completing her master's degree in elementary education, she worked as an elementary teacher in East Baton Rouge and Iberville Parishes. She then went to work as a case manager for Louisiana's Early Steps program where she worked with special needs children to help them access therapy services. In 2007, she began working for River Parishes Community College as an education instructor. She expects to graduate with a Ph.D. from the Louisiana State University School of Education in August 2016. After graduating, she plans on continuing a career in academia.