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Bridging the Gap: The Success of Underprepared Students in Developmental Mathematics and Subsequent College-Level Mathematics Courses

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BRIDGING THE GAP: THE SUCCESS OF UNDERPREPARED STUDENTS IN DEVELOPMENTAL MATHEMATICS AND SUBSEQUENT COLLEGE-LEVEL MATHEMATICS COURSES

By
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Approval Page

This dissertation was submitted by Pamela Edwards under the direction of the persons listed below. It was submitted to the Gardner-Webb University School of Education and approved in partial fulfillment of the requirements for the degree of Doctor of Education at Gardner-Webb University.

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Abstract

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Today, millions of students are entering higher education underprepared for college-level coursework. In the Southeastern Community College System, approximately 60% of the students were required to take developmental coursework prior to enrolling in college-level courses. Of these students, close to 30% enrolled in developmental mathematics courses. Attempts to improve success rates in these courses led the Southeastern Community College System to redesign the developmental mathematics program and determine college readiness using Multiple Measures. Implementation of these measures have changed the student demographics for developmental mathematics, which leaves to question: Who are the underprepared students? Research has shown that these students are students who are minority (Black or Hispanic), from low-income families, first-generation, and/or nontraditional. The purpose of this study was to examine the correlation between the demographical characteristics of underprepared students in developmental mathematics, success in subsequent college-level mathematics courses and persistence in the mathematics program. This study found a statistically significant association between the demographical characteristics of underprepared students and success and persistence. This study also found a statistically significant difference in the proportions of success and persistence of underprepared students based on the type of developmental mathematics program. The methodology used in this research study

consisted of the chi-square tests of independence and homogeneity, and post-hoc testing with Bonferroni corrections. Recommendations for future research are to include first-generation students and to expand the data collection to cover the academic years of the traditional and redesigned developmental mathematics programs.

Keywords: community college, developmental mathematics, underprepared students, redesign, self-efficacy

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Chapter 1: Introduction

Introduction

Education is the door of opportunity, as graduation from high school continues to be a milestone marking the threshold of adulthood for high school students transitioning from K-12 to postsecondary education. Many students enter institutions of higher education, whether through community colleges or universities, with the dream of furthering their education to obtain a degree, diploma, or certificate; however, that dream remains elusive for some students as the barrier of being underprepared detours their paths to graduation or transfer (Venezia, Kirst, & Antonio, 2003). For other students, attending college may be a different type of transition, returning for job training, changes in careers, or personal development. The different transitions into higher education become apparent when examining the student population of community colleges, as these institutions provide open door access to all students.

In most community colleges, the student population consists of students from very diverse backgrounds, as described in terms of ethnicity, social-economic status, and age; yet some of these students are not prepared for college-level coursework (Center for Community College Student Engagement, 2016). Boylan and Trawick (2015) described underprepared students as students who come from backgrounds of low income, students who are first-generation, minorities who have been underrepresented over time, and/or students for whom English is a second language. Therefore, in many institutions of higher education, students who are deemed underprepared, or not *college ready*, are required to enroll in developmental education programs before enrolling in college-level coursework (Bonham & Boylan, 2011). Developmental education is defined as a

combination of courses and services offered to students to support and prepare students for entrance into college-level courses (Kozeracki, 2002; Valentine, Konstantopoulos, & Goldrick-Rab, 2017). In general, underprepared students are students who are placed into developmental education as a result of low placement test scores (Barnett & Reddy, 2017). To support underprepared students to be successful, colleges and universities have instituted remedial or developmental education programs, with most United States higher education institutions offering at least one developmental course (Kozeracki, 2002).

Statement of the Problem

Since research has shown that approximately 58% of students entering higher education are underprepared for college and placed into developmental education, the plight of the underprepared student has become an important topic for administrators and state legislators (Attewell, Lavin, Domina, & Levey, 2006). This situation is especially true in the Southeastern Community College System (SCCS). Some initiatives that have been implemented over the last decade are Achieving the Dream (2012), the Developmental Education Initiative for 2011-2012, and the College and Career Ready Graduates, 2016-2017. One new change is the upcoming developmental education reform, RISE 2018. All of the initiatives were implemented to assist underprepared students with completing the course sequences, performing successfully in their subsequent or *gateway* college-level courses and to graduate (Parmer & Cutler, 2007).

More underprepared students enroll in developmental mathematics courses versus other courses offered through developmental education programs (Cafarella, 2014). As this type of course enrollment is the case in SCCS, these developmental education

initiatives have led to the redesign and reform of developmental mathematics in the community college system. The SCCS developmental mathematics curriculum was redesigned in the spring of 2011. The team for the math redesign represented 18 of the 58 community colleges in SCCS. The developmental mathematics course sequence for the redesign resulted in a change from four semester-long, 16-week courses to shorter eight 4-week modules (acceleration).

According to Attewell et al. (2006), 28% of underprepared students take developmental mathematics courses. In SCCS, students must successfully pass the developmental mathematics courses, as these courses serve as a prerequisite to entering the gateway college-level mathematics courses. Research has shown that as more students enroll in developmental mathematics, the rate of students completing college is quickly declining, as some of these students do not achieve their educational goals (Bonham & Boylan, 2011). These students are withdrawing or just dropping out, failing to complete the developmental mathematics course sequences, which means they are not being retained in the community college and do not persist to degree completion (Attewell et al., 2006). With increased attention on the number of underprepared students attending community colleges enrolling in developmental mathematics, there has been a growing need to focus on persistence and student success. As such, this study examined the relationship between developmental mathematics and the success of underprepared students in subsequent college-level mathematics courses. In addition, this study examined the relationship between developmental mathematics and student persistence to inform future changes needed in the developmental mathematics curriculum.

Background

American community colleges, formerly known as junior colleges, have been long-standing providers of education since their development in the early 1900s. Resulting from the Morrill Acts of 1862 and 1890, many of these colleges were initially developed as institutions for agriculture or training teachers (Cohen & Brawer, 1996). The initial purpose for community colleges was to provide educational programs for the expanding job markets; hence, community colleges continued to grow to meet societal demands for educating the workforce and the increasing number of high school graduates (Boylan, Brown, & Anthony, 2017; Cohen & Brawer, 1996).

At the onset, community college institutions were considered neighborhood schools and provided access to higher education for the high school graduates nearby as well as acceptance of students with prior low academic performance. In the mid-1940s, community colleges were charged to establish an open-door policy that would allow access for a diverse group of students such as minorities, women, and other students who did not perform well in high school. Additionally, the Commission also recommended provisions for financial assistance to help low-income students attend community colleges (Hutcheson, 2007). These recommendations by the Commission led to the delegation of general education to community colleges, which expanded access into these institutions for students later transferring to 4-year universities. Such policies have opened the door for students who otherwise would not have opportunities for postsecondary education, such as minorities, women, students with low income, and students who are low performing (Cohen & Brawer, 1996).

More students aspire to attend institutions of higher education than ever before

(Venezia et al., 2003); however, many of these students are underprepared for college-level coursework and are not college ready. Students entering higher education, underprepared for college, has been a long-standing occurrence since Harvard in the 17^{th} century (Cafarella, 2014). Many educators blame the lack of college preparation on the K-12 educational system, though measures to create better preparation standards arose with *A Nation at Risk* (Breneman & Haarlow, 1998; Venezia et al., 2003; Wilson, 2012). Preparedness for college results from high stakes standardized exams or placement tests, such as the ACCUPLACER or COMPASS, used to measure student achievement levels to determine if the student is ready for college-level coursework or if the student should be placed into developmental courses (Hughes & Scott-Clayton, 2011; Schak, Metzger, Bass, McCann, & English, 2017).

As such, students with low placement test scores are slated as not college ready or underprepared and are placed into developmental coursework before they can enroll in college-level coursework (Barnett & Reddy, 2017). Saxon and Morante (2014) described the importance of this process as the use of assessments, such as placement tests, must work in conjunction with the community college system to assist students with transitioning to being college ready. In addition, with the use of placement tests for course placement, it is essential to determine the interventions and courses necessary to help students prepare for college-level coursework.

The need for some type of intervention or remediation to prepare students has continued to rise since the 19^{th} century (Cafarella, 2014). According to Brothen and Wambach (2012), approximately 78% of all higher education institutions and 99% of all community colleges offer some form of developmental coursework. These course

offerings have been attributed to the fact that community colleges, with an open-door access policy, have experienced a greater need to attend to individuals who are underprepared for college. With an increase in the number of students needing developmental coursework, developmental education programs have incorporated a holistic approach to providing services to attend to the academic and personal development of students (Boylan, 1999).

Most developmental education programs consist of reading, writing, and mathematics courses, in addition to other services. As the number of students enrolling in developmental education courses continues to increase, community colleges and universities are seeking ways to reform developmental education programs by investing in faculty and courses (Boylan, Calderwood, & Bonham, 2017; Hall & Ponton, 2005). In 2008, approximately 42% of students entering the community college reported enrolling in at least one developmental course (Clotfelter, Ladd, Muschkin, & Vigdor, 2015). Data from the National Center for Educational Statistics (Kena et al., 2016) show that for the 2009 academic year, 48% of students entering community colleges enrolled in two or more developmental courses and approximately 26% of these students were enrolled in multiple developmental courses in various subjects. Additionally, approximately 59% of the students needing developmental coursework enrolled in developmental mathematics, whereas only 28% enrolled in English/writing developmental courses (Kena et al., 2016). Developmental mathematics programs are developed and implemented in the community colleges to assist students in achieving their academic goals, such as obtaining a degree or transferring to a 4-year university (Bonham & Boylan, 2011).

Research shows that high school math performance can be a good indication of

students' mathematical performance in higher education as well as future degree attainment (Burley, Butner, Anderson, & Siwatu, 2009). Hall and Ponton (2005) declared that student learning and success concern educators, as mathematics courses appear to determine the students' major in college as well as influence the likelihood of obtaining a college degree. This observation has led to an increased scrutiny of the developmental mathematics programs. With the large percentage of students enrolling in developmental courses, the relationship between these courses and the success of students who enroll in college-level coursework becomes a very important topic.

For example, prior to the redesign of the developmental mathematics courses in 2011, SCCS developmental mathematics courses were 16-week courses to be completed over the course of four semesters. Examination of these courses and student success across SCCS revealed that only 8% of the students placing in the lowest level developmental mathematics courses were actually completing the course sequence (Brown & Spies, 2015). In addition, approximately 67% of minority and low-income students were unequally affected (Brown & Spies, 2015). Therefore, improving student outcomes in developmental education, then, is not only important to increasing performance in specific courses, it may also increase the likelihood of term-to-term retention and degree completion (Parmer & Cutler, 2007).

Furthermore, timing for completion of the developmental courses becomes an issue. This concern for course completion was also a consideration for SCCS as research found that students could remain in the developmental mathematics sequence for more than four semesters, even years (Brown & Spies, 2015; Rutschow & Schneider, 2011). Since most developmental courses are not considered a part of the curriculum pathway

and do not count towards a degree, in some cases, students drop out or fail to complete their degree on time (Bettinger & Long, 2005; Schak et al., 2017). Extended time for graduation could lead to the loss of financial aid, as there are time constraints (Rutschow & Schneider, 2011). Further research is needed to determine the relationship between developmental courses and the success of developmental students in college-level coursework, in order for these courses to continue to be a part of the services for developmental education programs (Brothen & Wambach, 2012). As there will continue to be a need for developmental education, research on student success in developmental education and college-level coursework is and will remain a vital part of the community college.

Purpose of the Study

The purpose of this study was to determine the relationship between the characteristics of underprepared students in developmental mathematics and success in subsequent college-level mathematics courses. This study examined the relationship between the characteristics of underprepared students in developmental mathematics and persistence in the mathematics program. Research studies have been divided as to the effectiveness of developmental education in preparing students for college-level coursework (Goudas & Boylan, 2012). Some studies have shown that developmental mathematics students perform at similar levels to those students who have not enrolled in developmental mathematics courses (Fong, Melguizo, & Prather, 2015). In addition, one study found that developmental mathematics appears to improve the outcomes of students (Melguizo, Bos, & Prather, 2011); however, other research studies have developed the viewpoint that developmental mathematics has become a barrier to

college-level coursework and has not been helpful in assisting students to be any more successful than students who do not enroll in developmental mathematics courses (Bailey, 2009; Cafarella, 2014).

This study examined the correlation between the characteristics of underprepared students in developmental mathematics and student success and persistence. Currently, research suggests much more work is needed in the developmental mathematics curriculum to prepare students for successful completion of college-level mathematics courses (Parmer & Cutler, 2007). The goal of this study was to add to existing research of the overall relationship between developmental mathematics and the success and persistence of underprepared students in SCCS.

Setting

The research for this study was collected from the community colleges in SCCS. There are 58 community colleges in the state system. SCCS served as a good setting for this research study based on student populations and locations. There were approximately 800,000 students enrolled in curriculum and continuing education in these community colleges across the state. These sites are important to the study as the colleges are dedicated to student success, which is part of the mission of SCCS. Research from this study will be used to inform the developmental mathematics department on processes and changes to instructional practices as well as curriculum design to increase the success and persistence of underprepared students.

Definition of Key Terms

Several key terms are used throughout this study. In the educational field of study, the word *developmental* is used instead of *remedial* (Breneman & Haarlow, 1998)

and are used interchangeably. Other terms presented in this study are defined within the literature review.

College-level mathematics. The lowest level course for which college credit towards a degree is awarded (Bahr, 2008).

College readiness. College readiness is defined by GPA, success or placement test performance, and meeting the minimum requirements for college admission (Roderick, Nagaoka, & Coca, 2009).

Community college. Formerly junior colleges, a 2-year higher educational institution offering low cost continuing education and general education courses and associate degrees to the surrounding community (Burrows, 2016).

Continuing generation. Students attending college who have at least one parent with experience in postsecondary education (McFarland et al., 2017).

Developmental education. Boylan and Bonham (2007) described developmental education in broad terms of the courses and services administered to students for retention and progression to degree completion. Additionally, developmental education is a wide variety of practices created to prepare students for college-level coursework (Valentine et al., 2017).

Developmental mathematics. Current models for developmental mathematics include beginning math concepts for arithmetic through intermediate algebra (Boylan, 2011).

First generation. Students attending college whose parent/s have no experience in postsecondary education (McFarland et al., 2017).

Mathematics self-efficacy. An individual's perception of their capability to

solve math problems, complete math tasks, and perform in math-related coursework (Hackett & Betz, 1982; Liu & Koirala, 2009).

Multiple Measures. A policy using a hierarchy of measures to determine college readiness. The measures are an unweighted high school GPA of 2.6, ACT or SAT scores, or the placement test.

Performance. For the purpose of this study, performance is defined as success in subsequent college-level mathematics courses and persistence in the mathematics program.

Persistence (in the program). Continuous enrollment in an educational institution towards attainment of a degree, certificate, or diploma (National Student Clearinghouse Research Center, 2017). Comings (2007) defined persistence as adult learners staying in educational programs until they reach their educational goal.

Placement test. Standardized test such as SAT, ACT, ACCUPLACER, or COMPASS administered in higher education to determine college readiness of students (Barnett & Reddy, 2017).

Remedial courses. Remedial courses are defined as "noncredit courses that teach what is considered precollege content" (Boylan & Bonham, 2007, p. 2).

Remediation. For the purpose of this study, remediation is defined as coursework offered at a higher education institution (focusing mainly on community colleges) that is below college-level coursework (Parmer & Cutler, 2007).

Retention. Retain students in the community college to degree completion or transfer (Luke, Redekop, & Burgin, 2014; Tinto, 1987).

Self-efficacy. An individual's belief concerning their capability to produce or

perform (Bandura, 1994; Yurt, 2014).

Student success. Student success is defined as receiving a grade of C or better in college-level coursework. Grades below C do not transfer for college credit.

Subsequent, gateway courses. College-level courses which are the first-year credit bearing course for curriculum pathways (Goudas & Boylan, 2012). For this study, these courses will be the first curriculum or college-level mathematics course.

Underprepared student. For the purpose of this study, underprepared students are students who require one or more remedial or developmental education course prior to entering curriculum or college-level coursework. In addition, these students are described as low-income students, students who are first generation, minorities, and adult learners returning to school (Bulger & Watson, 2006). These students are also termed *at risk*.

Variables

Within the study, there are three independent variables and two dependent variables analyzed to determine correlation. For the purpose of this study, the independent variables are considered the characteristics of underprepared students. The independent variables examined are low income, nontraditional (over the age of 24), and minority (Hispanic and Black). Two dependent variables are examined, which are success, defined as a C or greater, in subsequent college-level mathematics and persistence in the mathematics program. Here, the mathematics program is defined as continuing to take developmental mathematics courses or enrolling in a college-level mathematics course. Performance, as defined in this study, is the examination of the success and persistence of underprepared students based on completion of the traditional

or redesigned developmental mathematics program.

Significance of the Study

Current research focused on the correlation of developmental mathematics and the success of students in college-level mathematics courses has yielded mixed results, as some students failed to complete the course sequence (Bailey, Jeong, & Cho, 2010). The significance of this study is to add to research on the relationship between developmental mathematics and student success. In addition, this study also sought to expound on possible relationships between in developmental mathematics students and persistence. The findings of this study could be used to assist with the reform of developmental mathematics on the community college campuses in SCCS to bridge the gap between developmental mathematics and college-level mathematics coursework of underprepared students.

Research Questions

This study focused on the success and persistence of students in developmental mathematics courses in SCCS. Examination of these concepts led to the development of the following research questions:

1. What is the correlation between the characteristics of underprepared students in developmental mathematics and success in subsequent college-level mathematics courses?
2. What is the correlation between the characteristics of underprepared students in developmental mathematics and persistence in the mathematics program?
3. How does the performance of underprepared students in subsequent college-level mathematics courses and persistence compare for students completing the

traditional or redesigned developmental mathematics course sequence?

Summary

The number of underprepared students entering the community college is continually increasing with more opportunities for access to higher education (Cafarella, 2014; Mulvey, 2009). As a result, more students are enrolling in at least one developmental mathematics course to obtain the necessary foundation to be successful in college-level mathematics courses. Therefore, more research is needed to determine if there is a relationship between the success of underprepared students in developmental mathematics and subsequent success in college-level mathematics courses. This study also focused on the relationship between developmental mathematics and the persistence of underprepared students to continue to college-level mathematics courses. A review of the literature surrounding developmental education theories, developmental mathematics models, the methodology used for this study, findings, and implications with recommendations will be presented in later chapters.

Chapter 2: Literature Review

Overview

SCCS is once again in the process of reforming developmental education. Previous models for developmental mathematics have been in the form of four 16-week courses (traditional) and then an accelerated 4-week (redesigned) course sequence of eight modules. The 2011 redesigned, accelerated curriculum was implemented in the spring of 2012 with the expectation of decreasing time spent in the developmental mathematics course sequence and improving student success in subsequent college-level mathematics courses. The literature review of the dissertation briefly describes the history of community colleges, SCCS, developmental education in SCCS, and a history of recent changes to developmental mathematics in SCCS. In addition, the literature review explores general characteristics of developmental mathematics students and factors relating to the success and persistence of these students. Currently, there is a plethora of research on these topics, singularly; however, this dissertation sought to utilize research, theories, and existing research studies as the foundation for the conceptual framework.

Conceptual Framework

The conceptual framework for this dissertation is grounded in three theories: the adult learning theory of Knowles (1974), the social cognitive theory of Bandura (1994), and Tinto's (1975) theory of student integration. These theories regarding student perceptions and experiences are examined to determine the ways in which research supports the relation to success and persistence of underprepared students in developmental mathematics. This framework is based on the conceptual understanding

of adult learners and the influence developmental mathematics may have on self-efficacy, which in turn, informs the success and persistence of adult learners in the developmental mathematics program. The conceptual framework for this study is shown in Figure 1.

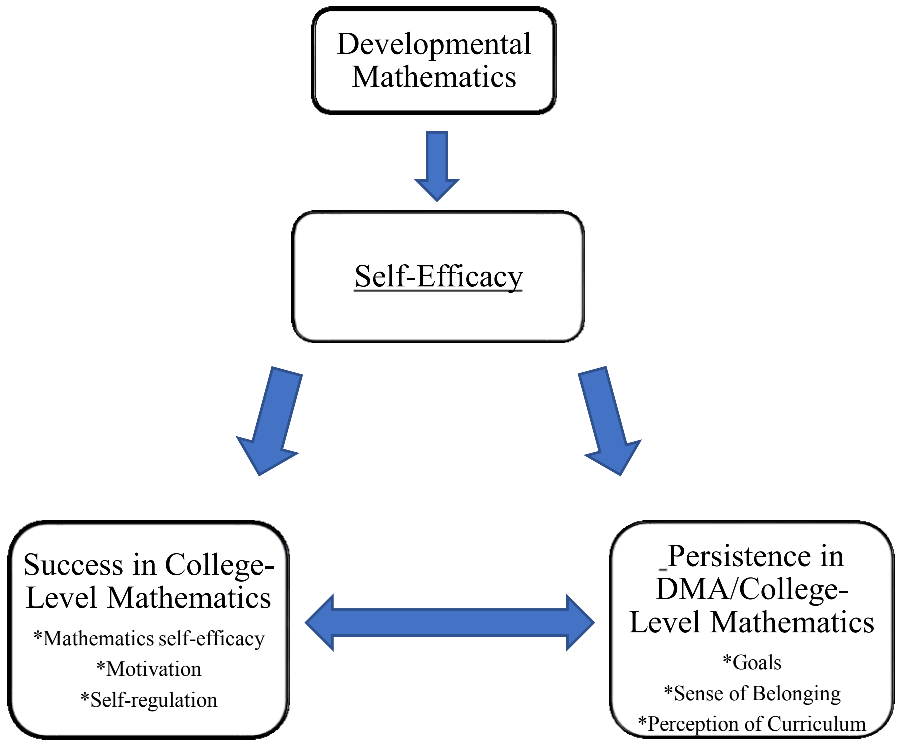

Figure 1. Conceptual Framework.

Figure 1 illustrates the proposed relationship between developmental mathematics, self-efficacy, success, and persistence. This study determined the relationship between these variables.

Knowles (1974) coined the term *andragogy* to be the study of adult learning. The adult learning theory of Knowles (1974) has been widely used in the development of programs designed for adults (Corley, 2011). Knowles's (1974) theory identified core learning principles attributable to adult learners as they (a) desire knowledge, (b) are self-directed learners, (c) draw on their experiences to assist in their learning, (d) possess a

readiness to learn, (e) tend to be problem centered and focus on relevance, and (f) are task or internally motivated (Corley, 2011; Knowles, Holton, & Swanson, 2012). These principles are believed to be central to designing and building effective programs for adult learning (Knowles et al., 2012). Comings (2007) declared that adult education programs should provide services that will help adult learners persist in learning programs until they reach their educational goals.

According to Bandura (1994), accomplishments and overall well-being are attributable to strong efficacy. The possession of strong efficacy leads individuals to persist through difficult challenges (Bandura, 1994); however, those who do not possess a strong sense of efficacy do not persist, give up, or avoid difficult challenges or tasks perceived as a challenge (Bandura, 1994).

Bandura (1994) defined four sources that influence self-efficacy. Self-efficacy is influenced by mastery experiences, vicarious experiences, modeling influences, and social persuasion, for a high or low sense of self-efficacy (Bandura, 1994). Bandura (1994) described self-efficacy as a person's belief in their ability to perform or achieve success through four main psychological processes: affective, cognitive, motivational, and selection. These processes guide the individual's emotions, thoughts, and actions through personal agency (Bandura, 1994).

One's self-efficacy affects the way in which the individual acts and functions in the form of the affective, cognitive, motivational, and selection process. Bandura (1994) described the affective process as the coping efficacy as it affects one's ability to deal with stress and depression and cope with various situations, as well as affecting motivation. Cognitive processes lead to behaviors, thoughts, and goal setting by assisting

the individual to process information for controlling how different events will affect one's life (Bandura, 1994). Self-efficacy in motivational processes guide the actions and beliefs of one's ability to perform as well as assisting with setting goals for future actions (Bandura, 1994). In addition, selection processes affect individual's choices for careers, development, and life pathways (Bandura, 1994).

The student integration or involvement theory of Tinto (1975) explained that as students become involved or integrated into the college atmosphere, they are more likely to persist and remain in the college. Student integration, defined as a sense of belonging, can occur from a social or academic aspect (Karp, Hughes, & O'Gara, 2011). Tinto (2016) also posited that persistence is related to self-efficacy, a sense of belonging, and the perception of the value of education. In addition, persistence can be related to institutional characteristics (Tinto, 1987).

Historical Background of Community Colleges

Community colleges in America date back as early as the 1800s with the Morrill Acts (Land Grants) of 1862 and 1890. With the inception of the Second Morrill Act of 1890, higher education institutions were charged to remove race as a criterion for admission into land grant institutions (Drury, 2003). These public colleges, during the 1900s, were termed junior colleges or 2-year colleges created to be agricultural institutions or teacher training colleges, providing education at a lower cost than private institutions (Cohen & Brawer, 1996). For some years, the term junior college was used to distinguish between private and publicly funded higher education institutions, until the 1970s, when the term community college was applied to both private and public 2-year institutions (Cohen & Brawer, 1996); however, the ongoing issue of junior colleges as an

extension of secondary education or institutions of higher education remained an important factor in establishing the function of these institutions. Furthermore, there was a significant increase in junior college enrollment as a result of the Great Depression, the GI Bill of Rights for veterans to attend junior colleges, a desire for social and economic mobility, and increasing numbers of high school graduates (Drury, 2003). Harvard president Conant and others proposed the idea that junior colleges should be considered terminal higher education institutions, as an extension of high school and providers of vocational training (Cohen & Brawer, 1996; Drury, 2003).

In 1946, near the end of World War II, President Truman appointed the Commission on Higher Education (Hutcheson, 2007). In 1947, the Truman Commission recommendations transformed junior colleges into community colleges, thereby defining the purpose of these colleges as to serve the surrounding community by providing programs and services which meet the needs of the community (Franco, 2006). These junior colleges served as cultural centers and provided low-cost education and training for those entering the technical, vocational, and business industries (Dougherty, Lahr, & Morest, 2017; Drury, 2003). In addition, the Commission believed that finances served as a major barrier to students from families with low incomes; therefore, it recommended that the federal government provide financial assistance to these students to afford them equal opportunity for higher education (Gilbert & Heller, 2010). These recommendations were based on the premise that such practices would restrict higher education to students from families with high incomes and create a class society (Gilbert & Heller, 2010). A second critical recommendation made by the Commission was to provide an open door for access to higher education for all students regardless of race, religious beliefs,

national origin, sex, or color (Hutcheson, 2007).

With these recommendations, there were definite changes in the student population and a need to revise the colleges' approach to teaching this diverse group of students (Hutcheson, 2007). Junior college institutions were now open to students who were from families with low income, minorities, and students who had poor prior academic performance. In other words, junior colleges provided new opportunities for students who previously did not have access to higher education (Cohen & Brawer, 1996). Junior colleges, later to become community colleges, continued to grow throughout the 1950s and experienced a great surge in enrollment in the 1960s as baby-boomers were attending college, more parents were sending their children to school, and others enrolled in attempt to avoid the draft for the Vietnam War (Jurgens, 2010). With the growth in enrollment, many students were entering junior colleges academically underprepared to successfully complete college-level coursework (Hutcheson, 2007).

Such occurrences led to colleges offering courses for study skills and reading to assist these students (Cafarella, 2014). During the 1970s and 1980s, enrollment grew once again as more women and adult students enrolled in junior colleges, now community colleges, and these institutions shifted in focus to vocational education, workforce training, and transfer (Franco, 2003). Also, these years of college attendance gave rise to developmental education programs (Cafarella, 2014). By the 1990s, there were more than one million students enrolled in the nation's approximately 1,100 community colleges (Cohen & Brawer, 1996). Today, there are approximately 1,200 public, private, and tribal community colleges enrolling approximately 11.6 million or 46% of all the nation's undergraduates and offering associate degrees, certificates,

diplomas, and university transfer (Jurgens, 2010). In addition, there has continued to be a surge of colleges offering developmental education programs to serve underprepared students (Cafarella, 2014).

Brief History of SCCS

Southeastern experienced a drastic change in its economy from agriculture to industry after World War II, leading to a focus on education. Citizens of the state needed to have more than a high school diploma. Dr. Allan S. Hurlburt published a proposal to create community colleges supported by the state in 1952. In 1957, the General Assembly of Southeastern developed the Community College Act which provided the state community colleges with the operational funding. Development of this act resulted from the realization that there were not enough skilled and educated workers for jobs in banking, financial services, manufacturing, and technology (Brown & Spies, 2015).

The General Assembly also funded industrial education centers to provide skills and training for adults and high school students to meet the needs of the industry. By 1961, there were 12 educational centers. In 1962, the educational centers merged into one system, SCCS, overseen by the State Board of Education and local boards of trustees. By 1963, there were six community colleges and 25 other educational centers. SCCS continued to grow to 43 educational institutions with over 28,000 students by 1966.

Since 1978, there were 58 community colleges with the control of the colleges relegated to the Southeastern Department of Community Colleges in 1981. Performance measures for the accountability and state funding of the community colleges were instituted in 1993. These measures were revised in 2010, and the current performance measures are

a) Basic Skills Student Progress

b) Developmental Student Success Rate in College- Level English Courses

c) First Year Progression

d) Licensure and Certification Passing Rate

e) GED Diploma Passing Rate

f) Developmental Student Success Rate in College- Level Math Courses

g) Curriculum Student Completion

h) College Transfer Performance.

To date, SCCS has had a total of nine presidents serving various terms. Currently, there is an interim president overseeing the community college system. Today, SCCS is the third largest higher educational system in the nation with enrollments of more than 800,000 students each year (Brown & Spies, 2015).

Developmental Education in SCCS

Since its growth to 58 community colleges, SCCS has served as an open door to students with various goals and academic needs for their chosen course of study. Many of these students enter underprepared, or not ready for college; and over the years, developmental education has continued to be an area in which these students struggle (Brown & Spies, 2015). Developmental education in SCCS consists mostly of math, reading, and English courses, as these are the areas in which underprepared students have historically experienced greater deficits (Brown & Spies, 2015). Developmental education programs have been in existence for many years to provide underprepared students with learning support and a variety of interventions necessary to assist these students with being successful in higher education (Boylan, 1999; Cafarella, 2014).

Some research shows that only about 20% of students who pass developmental courses continue on to college-level coursework (Rutschow, Diamond, & Serna-Wallender, 2015; Templin, 2011); however, other research has shown that approximately 70% of developmental education students in community colleges successfully complete the course sequences (Kozeracki, 2002). State legislators and policy makers have begun to recognize the importance of improving developmental education to ensure the success of higher education (Boylan & Bonham, 2007). Boylan (1999) declared that developmental education programs give underprepared students an equal chance at success in community colleges.

Placement testing. College readiness is the term used to describe students in possession of personal and intellectual capabilities necessary for successful performance in a postsecondary institution (Levine-Brown, Bonham, Saxon, & Boylan, 2008). Many students leave high school without the necessary academic skills to be successful in college (Boylan, 1999). In other words, these students are not ready for college or they are academically underprepared for college. For these students, upon entering the community college, a placement test such as the ACCUPLACER or COMPASS is required to determine that level of unpreparedness. Based on the scores received from the placement test, underprepared students may be required to take several developmental courses prior to enrolling in curriculum-level English or mathematics courses (Bailey et al., 2010). Approximately 68% of students attending community colleges are placed in at least one developmental course (Jaggars & Stacey, 2014); however, the criteria for placement varies across the community college system (Clotfelter et al., 2015).

In addition, the effectiveness and validity of placement tests have been under

scrutiny (Rutschow & Schneider, 2011; Scott-Clayton, 2012). The ACCUPLACER placement test is used in 62% of the community colleges (Scott-Clayton, 2012). Data collected from one urban system show the error rate for placement into developmental mathematics was 21% (Community College Research Center [CCRC], 2013). Many educators believe that sole reliance on one test has led to a large number of misplaced students (Crisp & Delgado, 2014). Additionally, some students who place into developmental education could be successful in college-level courses (Fain, 2012). As such, SCCS revamped the placement testing process and implemented a new test for determining the need for developmental education in March 2016. The new placement test is the Southeastern Diagnostic Assessment and Placement Test (SDAP) which assesses college readiness and determines the developmental courses needed in English, reading, and mathematics according to the academic skill level of the student. In addition, SCCS has also implemented a new policy to determine college readiness for recent (less than 5 years) high school graduates.

Multiple Measures. For Multiple Measures, recent high school graduates must have an unweighted high school GPA of 2.6 and ACT minimum cutoff scores of 22 for reading and mathematics and 18 for English or SAT scores with a minimum cutoff score of 480 for evidence-based reading and 530 for mathematics. Community colleges in SCCS began implementing the Multiple Measures policy in the fall of 2013, with full implementation in the fall of 2016. With this measure, students who meet the requirement bypass developmental education leading to a decrease in enrollment in the developmental course sequences (Boylan et al., 2017; Grovenstein, 2015). Though the results of student placement under this policy are not yet known, policy makers have to

rely on research from other community colleges (Ngo & Kwon, 2014). A study from a community college in the Los Angeles Community College District using linear probability regression found that the use of high school GPAs as a multiple measure was a greater indicator of college readiness and student outcomes for college completion (Ngo & Kwon, 2014).

Developmental Mathematics

Developmental mathematics courses are instituted as a part of developmental education to enhance the academic skills of underprepared students for college-level mathematics courses (Bailey et al., 2010). The need for developmental mathematics has increased as more students are required to enroll and complete the course sequence prior to enrolling in college-level mathematics courses (Bonham & Boylan, 2011), yet research has shown that more than 65% of these students do not complete the developmental mathematics sequences (Cullinae & Treisman, 2010). Given these alarming statistics, more research was needed on the success of those students who do complete the course sequence and continue to college-level mathematics courses. Moreover, further research has shown that students who successfully complete the course sequence perform at similar levels as those students who did not require developmental mathematics (Bahr, 2008). The developmental mathematics course sequence consisted of four semester-long (or 16-week) courses ranging in topic from basic mathematical skills to intermediate algebra. Successful completion of this sequence should lead students into gateway mathematics courses. Success in a developmental mathematics course is a grade of P, as the grading scale is pass/fail. With increased attention on student success in developmental mathematics, change was inevitable (Bonham & Boylan, 2011), as some

believed that redesigning developmental education could increase student success in college-level mathematics courses (Brothen & Wambach, 2012).

Redesign of SCCS Developmental Mathematics

Across the country, in most community colleges, students in developmental mathematics fail to complete the course sequences, thereby never taking a college-level mathematics course or obtaining a degree (Stern, 2012). In 2009, Southeastern joined five other states in an initiative funded by Bill and Melinda Gates and the Lumina Foundation to implement processes to decrease the need for developmental education, decrease the amount of time it took for students to complete the course sequence, and to implement measures for more accurate assessment and placement (Brown & Spies, 2015). Through the listening tours and follow-up meetings, prior to the redesign, data indicated that only 8% of the students who were placed in the lowest level of developmental mathematics (fourth course) continued to successfully complete a college-level mathematics course (Brown & Spies, 2015). Bailey et al. (2010) posed that 42% of developmental mathematics students do not enroll in the next course in the sequence. Other research supported the fact that the previous structure of the traditional design for developmental mathematics created a barrier to student completion (Edgecombe, 2011). Such troubling statistics served as a catalyst to the redesign and the Developmental Education Initiative.

To begin the redesign, 18 educators were nominated from the 58 community colleges in the system to serve on the Math Redesign Task Force. These educators met with a common set of principles to guide the redesign of the developmental mathematics program. The principles that would guide the redesign included the following:

- Modular approach
- Time for curriculum completion is one academic year
- Flexible curriculum requirements for completion appropriate to the needs and knowledge of the students
- Diagnostic testing for appropriate placement in modules
- Implementation of the curriculum aligned with needs and resources of college, and
- Modules fully consist of contextual and conceptual understanding.

In addition to these principles, the redesigned curriculum would consist of eight one-credit modules focused on mastery of the concepts, conceptual and contextualized learning (Brown & Spies, 2015). Each of the eight modules would be delivered in 4-week terms. This redesigned framework would allow a student to instantly retake a module upon failure without having to wait for the next academic semester. In addition, students could exit the module sequence at any point based on the course or academic pathway for the student (Edgecombe, 2011).

Delivery methods for instruction for the modules were left to the discretion of each community college. Methods employed for instructional delivery are the traditional face-to-face method; internet or web-based design with face-to-face testing for mastery; or computer-centered design, Emporium. Despite the delivery method, each module offered incorporates a mathematics software component for additional practice on concepts.

Acceleration. Community colleges have been slowly implementing accelerated developmental course sequences to assist students in taking less time to reach gateway or

college-level courses (CCRC, 2014). The CCRC (2014) described acceleration strategies as strategies that will limit exit points and time spent in the developmental course sequence.

Edgecombe (2011) declared that acceleration is reorganizing teaching and curricula to “accelerate” the path to college-level coursework and possibly improve outcomes for developmental students. As such, students can complete the requirements for developmental courses in one semester or less (Cafarella, 2014).

Advocates for acceleration believe it will increase the likelihood that students will not drop out and will continue to complete the developmental sequences and enroll in college-level courses (CCRC, 2014); however, opposition poses that acceleration is not a fair trade-off for the traditional sequences for underprepared students (Edgecombe, 2011). Essentially, underprepared students require more time to completely master the concepts contained within the developmental mathematics curriculum (Edgecombe, 2011). In addition, some believe this practice could lead to failure for the underprepared students resulting in noncompletion of the developmental sequences (Edgecombe, 2011).

Studies for the results of acceleration in the community colleges reveal several differences in the approach to acceleration in terms of curriculum content, instructional methods, and student support services (Edgecombe, 2011). One study, using the FastStart program, found that these students were more likely to complete college-level mathematics courses; however, the success rates between students in the traditional and accelerated programs did not vary (Edgecombe, 2011).

Modularization. Modularization is the process adopted by SCCS in the redesign. In this process, three traditional developmental mathematics courses were divided into

eight 4-week modules to increase enrollment and completion of the developmental mathematic sequence in a timely manner. Research shows that students were inadvertently "stuck" in the sequence for many semesters or even years (Rutschow & Schneider, 2011). The developmental mathematics sequence was divided using learning outcomes to ensure conceptual understanding. These modules are

1) Operations with Integers
2) Fractions and Decimals
3) Proportions, Ratios, Rates, and Percents
4) Expressions, Linear Equations and Inequalities
5) Graphs and Equations of Lines
6) Polynomials and Quadratic Applications
7) Rational Expressions and Equations
8) Radical Expressions and Equations

Research on the redesign in SCCS has shown that student success rates are higher than in the traditional sequence (Brown & Spies, 2015). In addition, data have shown that pass rates in gateway courses increased by 21% (Brown & Spies, 2015). Students in the redesigned course sequence tend to complete the sequence faster by demonstrating mastery with the final tests (Boylan et al., 2017). One way in which the modules are believed to shorten time in the developmental sequence is to allow the students to take only the modules needed to solidify academic skills necessary for success in college-level mathematics courses (Edgecombe, 2011). The modules allow students to exit the sequence and continue to college-level mathematics courses at a much faster pace; however, due to various differences in student motivation and prior academic skills,

further research is needed to determine if acceleration or modularization actually increases student achievement (Rutschow & Schneider, 2011).

The Virginia Community College System found that the success rates for students in college-level mathematics courses increased by 10% in 2012, whereas student success rates in developmental mathematics increased from 35% to 40% in 2014 (Boylan et al., 2017). A second community college, Jackson State Community College, which employs a modularized approach with mastery, claims increases in posttest scores of 15% and 44% in course pass rates (Boylan et al., 2017). In addition, the curricular redesign or acceleration of the developmental statistics program at Los Medanos College declares an overall 59% completion rate (Boylan et al., 2017). Through examination of those students who placed into the lowest levels of developmental mathematics, 39% successfully completed the statistics course, whereas only 5% of the traditional sequence students successfully passed the course (Boylan et al., 2017).

Mastery. Mastery is a key element in redesigned developmental mathematics programs (Kalamkarian, Raufman, & Edgecombe, 2015). The purpose of the redesign is to ensure that students quickly progress through the sequences while developing mastery of the concepts for each module taken in the sequence. Students demonstrate mastery by completing the assignments and assessments for each module to progress to the next module needed or to college-level mathematics (Kalamkarian et al., 2015).

Mastery for the SCCS redesigned developmental mathematics courses is 80% on the final assessment. In addition, the SCCS developmental mathematics modules incorporate a conceptual and contextualized approach to curriculum to increase opportunities for mastery. Students who fail to demonstrate mastery on the final

assessment for a module can take a second assessment after remediation. Implementation of mastery for the redesign ensures that students are prepared for subsequent college-level mathematics courses (Kalamkarian et al., 2015).

Contextualized learning. One form of contextualized learning is described as combining basic skills with content from other courses (Rutschow & Schneider, 2011). As it relates to developmental education, contextualization adds meaning to the content (Edgecombe, 2011) as well as incorporating vocational content (Rutschow & Schneider, 2011). The use of contextualization in developmental courses is believed to improve outcomes for academically underprepared students (Perin, 2011). Based on the adult learner theory, including information from other texts and courses into the developmental education curriculum increases the opportunity for adult learners to experience relevance (Kenner & Weinerman, 2011). Perin (2011) posited that the goal of contextualization is to enhance student learning of concepts to continue to build to higher level coursework.

Research related to contextualization has shown that the use of contextualization in developmental mathematics courses led to an increase in math scores (Perin, 2011). One study conducted specifically to determine the effectiveness of contextualization in community colleges in California employed logistic regression, controlling for demographics, to examine basic skills and pass rates for students in a contextualized vocation developmental mathematics course (Edgecombe, 2011). The results of the study revealed that the basic skills and pass rates were higher among students in a contextualized course; specifically, 89% of these students passed compared to only 59% of students not enrolled a contextualized course (Edgecombe, 2011).

The SCCS redesign incorporated four key components: acceleration,

modularization, mastery, and contextualization. As the redesign is nearing the fifth full year of implementation, a limited number of studies have been conducted to determine the success of students in the transitional model compared to the redesign (Brown & Spies, 2015); therefore, much of the research on the effectiveness of modularization and acceleration has been conducted in other institutions.

Characteristics of Underprepared Students in Developmental Mathematics

Community colleges continue to provide open access to higher education for a diverse group of students, many with academic deficiencies. The process for improving student success and persistence in developmental mathematics programs will require an in-depth analysis of the students who enroll in developmental education, especially developmental mathematics courses (Benken, Ramirez, Li, & Wetendorf, 2015). Research pertaining to developmental education describes students who place into developmental education as “underprepared” (Schak et al., 2017). Additional research describes these students as at risk for failure (Mulvey, 2009). Approximately 67% of students entering higher education are underprepared for college-level coursework (Boylan, 1999). Most reforms and redesigns of developmental education are implemented to improve success in subsequent college-level courses; however, these innovations do not consider the characteristics of the underprepared student (Boylan et al., 2017). What are the characteristics of underprepared students? These students have been described by many as students who come from low-income families, minority, first-generation, and older than traditional (18-24 years of age) students (Boylan et al., 2017; Boylan & Trawick, 2015; Mulvey, 2009). Black and Hispanic students have been academically underprepared for much of their educational mathematics careers and do

not graduate with the same level of academic skills as White and non-Hispanic students (Bahr, 2008; Venezia et al., 2003). For example, the Southeastern High School Report Card (2015) shows that during the 2015 and 2016 academic years, only 38.1% of Black students and 49.7% and 49.8% of Hispanic students in the public high schools were considered grade-level proficient in mathematics. Furthermore, low-income students also failed to obtain the academic skills necessary to be successful in college-level coursework.

To assist in preparing these students to be successful and to persist in college-level coursework, it is necessary to understand why these students are underprepared. Examination of prior academic history of underprepared (first-generation, minority, low-income, and nontraditional) students has shown that though these students graduated from high school, graduation does not guarantee preparation for college-level coursework (Butrymowicz, 2017; Venezia et al., 2003). One study has identified the source of college under-preparedness as resulting from a disconnect between the public K-12 and postsecondary school systems (Venezia et al., 2003). According to Southeastern High School Report Cards (2015), 26.9% of Black students and 38.2% of Hispanic students were considered college and career ready. In addition, research supports these findings by noting the misalignment of the requirements between high school completion and entrance into higher education ("Closing the Gap," 2011). Advising remains a critical component of preparing students for college-level coursework during high school and in community colleges, as studies show that underprepared students lack access to college-level advising and college preparatory classes (Karp, 2011; Venezia et al., 2003). Another crucial reason cited as to the cause of under-preparedness in first-generation,

minority, low-income, and nontraditional students for college-level mathematics courses is the failure of these students to take college preparatory mathematics courses in high school (Venezia et al., 2003).

There have been long-standing achievement gaps in mathematical achievement for underprepared students. As such, one study examined the success of underprepared students in developmental mathematics courses (Quarles & Davis, 2016). This study was completed on traditional sequence courses incorporating a pre and posttest design to examine the relationship between learning in the developmental mathematics sequence and progression toward a degree (Quarles & Davis, 2016). Participants were given an assessment consisting of algebra skills. The data analysis included descriptive statistics, linear regression, and logistic regression. Findings showed learning gains in procedural scores were up by an average of 34.2% (Quarles & Davis, 2016). Conceptual scores improved by 9.6%, and there was significant correlation between the procedural posttest results and student grades ($r = .423$, $p < .001$, $n = 107$). Conceptual posttest results showed no correlation ($r = .010$, $p = .917$, $n = 107$). The study also found that grades in previous math classes were a significant indicator of grades in precalculus (Quarles & Davis, 2016).

First generation. First-generation students are students who are first in their families (as it relates to parents) to attend an institution of higher education (Wirt et al., 2005). Approximately 50% of students attending institutions of higher education are first-generation students (Hirudayaraj, 2011). Further research has indicated that these students have to overcome more obstacles than continuing generation students (Ruffalo Noel Levitz, n.d.). One obstacle these students face, due to the lack of parental

education, is the absence of the understandings and expectations for maneuvering within the college arena (Byrd & MacDonald, 2005; Hirudayaraj, 2011). This lack of college knowledge is a considerable disadvantage for these students and eventually leads to financial issues and early drop out (Nunez & Cuccaro-Alamin, 1998; Pascarella, Pierson, Wolniak, & Terenzini, 2004; Ruffalo Noel Levitz, n.d.). According to Redford, Ralph, and Hoyer (2017), only 17% of these students obtained a bachelor's degree.

Low income. Low-income students are students whose family income is below 150% of the poverty line (U.S. Department of Education, n.d.). Students from low-income families are not as likely to complete college, with only 14% of these students obtaining at least a bachelor's degree in 8 years (College for America, 2017). Many low-income students enter community colleges through developmental education programs (Dougherty & Reid, 2006). These students also face additional barriers to access and completion for higher education, such as the lack of financial knowledge and capabilities to navigate the college process (College for America, 2017). These financial barriers often lead to early drop out as these students get jobs to support themselves or accrue debt (Boylan et al., 2017; College for America, 2017).

Nontraditional. Nontraditional students are generally defined as students over the age of 24; however, other factors are also used to define nontraditional students (Kena et al., 2016). These factors are full-time employment, dependent children, enrolled part-time, and financial independence (Kenner & Weinerman, 2011). Nontraditional students account for approximately 40% of undergraduate students (Hittlepole, n.d.). Oftentimes, the lack of a sense of belonging in the college serves as a barrier to these students (Hittlepole, n.d.). Research regarding nontraditional students reveal that many of these

students have additional barriers such as work and/or are married with children (Crosta, 2013). Nontraditional students also tend to require enrollment in developmental education (Snyder, de Brey, & Dillow, 2018). Additionally, the drop-out rate for nontraditional students increased to 34% for students over the age of 27 compared to 18% for nontraditional students between the ages of 20 and 26 (Crosta, 2013).

Minorities. For the purpose of this study, minorities are defined as students who are Black or African American and Hispanic as these ethnic groups represent a disproportionate number of students enrolled in developmental education (Bahr, 2008). Approximately 58% of Hispanic students and 57% of Black students were underprepared for college-level courses and enrolled in developmental education between 2010 and 2014 (Schak et al., 2017). Furthermore, approximately 61% of Black students and 52% of Hispanic students leave the community college without ever obtaining a degree (Dougherty & Reid, 2006).

Race, gender, socioeconomic status, and class are all variables that have been associated with drop out and low completion rates (Barbatis, 2010). More research is needed to develop a deeper understanding of how to meet the needs of these students to engender academic success, as recent reports reveal more first-generation students enroll in developmental education than continuing generation students (Chen, 2016). Additional research is required, as underprepared students are most likely placed into developmental courses to assist with college completion; yet many of these students fail to obtain a degree or certificate (Bettinger, Boatman, & Long, 2013).

A study focused on the success of developmental mathematics, as it relates to the racial differences, found that some disparities in mathematics preparation can be

attributed to several factors: low-income families, minorities, and need for developmental mathematics (Bahr, 2010). The data used for this study were gathered from the state office of community colleges and consisted of transcripts, demographics, financial aid awards, and credential awards cross-referenced with enrollment (N = 70,078). Of these, the racial groups were White, Black, Hispanic, and Asian (Bahr, 2010). Cleaning up the data left a remaining 63,147 students. The study incorporated five student-level controls and four college-level controls and used nested two level hierarchical logistic regression. In addition, bivariate analysis was used (Bahr, 2010). The findings for the study revealed that White students were 3.1 times more likely to successfully remediate compared to the Black students and 1.6 times more likely to successfully remediate than the Hispanic students. Asian students were 1.2 times more likely to successfully remediate than White students. The success rates for remediation were low at 24.6% for completing a college-level mathematics course within 6 years of enrollment (Bahr, 2010).

External Factors on Student Success

Student thoughts, actions, and performance are guided by several factors. With the goal of developmental courses to prepare students to succeed in college-level mathematics courses, these courses should be designed based on factors and skills needed to be successful and to implement practices to develop these factors and skills in students (Quarles & Davis, 2016). Some of these factors are grounded in the theory of adult learners (Knowles, 1974), motivation and self-regulation (Usher & Pajares, 2008; Zimmerman, 2008; Zimmerman & Schunk. 2008), self-efficacy (Bandura, 1994), and mathematics self-efficacy (Jafaar & Ayub, 2010). These factors coincide with four psychological processes, described by Bandura (1994) as the affective, cognitive,

selection, and motivational processes to impact academic performance.

Adult learning. Knowles (1974) developed the adult learning theory based on several characteristics attributable to adult learners. These principles of adult learners are presented in Table 1.

Table 1

Principles of the Adult Learning Theory

Principle	Description
1. The Need to Know	Adult learners need to know why they should learn a concept.
2. The Learner's Self-Concept	Adult learners have a self-concept of being responsible for their own learning.
3. The Role of the Learner's Experiences	Adult learners draw on their life experiences for learning.
4. Readiness to Learn	Adult learners are ready to learn to deal with life's situations.
5. Orientation to Learning	Adult learners are task oriented.
6. Motivation	Adult learners are motivated to learn when applicable to obtaining a better quality of life.

Knowles, Holton, and Swanson (2005).

The Adult Learning Theory posits that adult learners are different in many respects from the traditional student. Knowles's (1974) first principle of adult learners is the need to understand why the learning matters. Solidifying the reasons for learning a concept assists adult learners with putting forth the effort to perform well. Second, adult learners are self-directed and have self-concept. Developing the characteristic of being self-directed in adult learners helps them to take responsibility for their learning and to be willing participants in the learning process. A third principle, identified by Knowles

(1974), is that adult learners draw on their life experiences to assist with learning. As adult learners have a varied history of life experiences, adult educators assist these learners to develop self-identity. For the fourth principle (Knowles, 1974), adult learners possess a readiness to learn. Adult educators can use this characteristic to influence adult learners with being ready to learn new concepts. The fifth principle of Knowles's (1974) adult learning is an orientation to learning. This principle describes adult learners as problem or task oriented as they center learning around life's situations. The last principle of Knowles (1974) was the characteristic of motivation. Adult learners are internally motivated, though they can also be extrinsically motivated by jobs, future, and family.

Self-efficacy. In the social cognitive theory, Bandura (1996) posed that beliefs of one's individual ability is an important factor for *human agency*. Human agency is the ability to exert control over one's surroundings and social structures (Bandura, 1996). Self-efficacy is the belief in one's ability to perform a specific task or influence events (Bandura 1994). Self-efficacy also determines the individual's ability to recover from a setback, whether the process will be quick or prolonged (Bandura, 1994). In addition, self-efficacy leads one to make choices concerning actions, whether the individual will practice engagement or avoidance for a specific task (Bandura, 1994). According to Pajares and Schunk (2001), self-efficacy becomes a motivation, predictive of academic performance. In addition, the concept of self is believed to be a critical component of academic motivation (Pajares & Schunk, 2001).

Bandura (1989) found that individuals with a high sense of self-efficacy were motivated to choose actions or tasks in which the individual was challenged. These

individuals also remained focused on the task at hand to see it through to completion (Bandura, 1989). On the other hand, individuals with a low sense of self-efficacy would not remain with the task and would give up as they perceive themselves as a failure (Bandura 1989). Research on self-efficacy has shown that processes in which an individual visualizes either a success or defeat plays a determining factor in the performance outcome (Bandura, 1989; Pajares & Schunk, 2001); therefore, one of the most important components of developmental mathematics programs is to increase the self-efficacy of students in developmental mathematics courses (Baxter, Bates, & Al-Bataineh, 2017).

Bandura (1994) declared that self-efficacy beliefs are developed through mastery experiences, vicarious experiences, modeling influences, and social persuasion. These experiences can determine whether an individual develops a strong or weak sense of self-efficacy. In mastery experiences, successes and failures are key to developing a resilient sense of self-efficacy in which the individual obtains experience in overcoming obstacles and comes out stronger (Bandura, 1994). Vicarious experiences provided through social model can help to develop a strong sense of self-efficacy by showing success, allowing the individual to believe that he or she is also capable of succeeding in the same or a similar activity (Bandura, 1994). According to Bandura (1994), modeling influences are similar to role models by which an individual learns skills for managing life's events. The last way in which individuals can develop self-efficacy is through social persuasion. Self-efficacy is developed or strengthened by encouragement or words of persuasion leading the individual to believe that he or she can succeed (Bandura, 1994).

Bandura (1994) described how belief in one's self-efficacy affects the way in

which the individual functions through the cognitive, affective, motivational, and selection processes. Cognitive processes are thoughts in which an individual will predict and construct ways to control life's events (Bandura, 1994). Cognitive processes also assist individuals to set goals. Affective process is the individual's belief in the ability to cope and control stressors (Bandura, 1994). Motivational process is the belief in one's ability and thoughts generated toward actions (Bandura, 1994). Selection processes are the beliefs of efficacy that determine choices of careers (Bandura, 1994).

Self-efficacy affects motivation, choices and actions, and resiliency in the face of adversity and challenges (Bandura, 1994). A strong sense of self-efficacy is necessary to succeed, as this sense of efficacy leads to academic accomplishments (Bandura, 1994; Pajares & Schunk, 2001).

Mathematics self-efficacy. Self-efficacy is the belief in one's ability to complete a task or to perform to a certain standard (Bandura, 1994) and is important to academic achievement (Hall & Ponton, 2005). Research has shown that self-efficacy can impact a student's mathematics performance (Jafaar & Ayub, 2010). Mathematics self-efficacy is a student's belief to be able to successfully solve mathematics problems (OECD, 2015). In support of the statement by Jafaar and Ayub (2010), research shows that student perceptions of their mathematics self-efficacy affect mathematical performance (Akin & Kurbanoglu, 2011). Given the relationship between mathematics self-efficacy and mathematical performance, it is desirable for developmental mathematics to increase the mathematics self-efficacy, as it could also lead to an increase in student mathematical ability (Baxter et al., 2017). Students with a high sense of mathematics self-efficacy will expend more time and effort on mathematical concepts (Bandura, 1994; Jameson &

Fusco, 2014). Students with a low sense of mathematics self-efficacy will give up and avoid mathematical tasks (Akin & Kurbanoglu, 2011; Bandura, 1994; Pajares & Schunk, 2001).

A low sense of mathematics self-efficacy leads to negative attitudes which encourage math anxiety (Akin & Kurbanoglu, 2011; Bandura, 1994). As the relationship between mathematics self-efficacy and mathematics performance is reciprocal, increasing student opportunities for success could increase student mathematics self-efficacy (OECD, 2015). Mathematics self-efficacy affects student persistence and motivation in mathematics (Benken et al., 2015).

A study was conducted on the mathematics self-efficacy of adult learners. Adult learners are different from the traditional college student in terms of age, work, and family commitments (Jameson & Fusco, 2014). In this study, the participants were undergraduate students, ranging in age from 18 to 59 years old (Jameson & Fusco, 2014). Sixty of these students were classified as traditional college students, and the remaining 166 were classified as adult learners ($n = 226$). Demographics for the students show 76% Caucasian, 16% African American, 3% biracial, 3% Middle Eastern, 1% Hispanic, and 0.5% other. Students were given the Abbreviated Math Anxiety Scale with nine items, Likert scale with 1 = low anxiety to 5 = high anxiety (Jameson & Fusco, 2014). The test had an internal consistency (Cronbach's $\alpha = .90$) and a reliability of $r = .85$. To test mathematics self-efficacy, the Mathematics Self-Efficacy Scale was used with a similar Likert scale of 1 = not confident at all and 5 = very confident. Additionally, the participants mathematics self-concept was assessed (Jameson & Fusco, 2014). The study employed Hotelling's T to explore the differences in math anxiety, efficacy, and concept.

The results of the analysis revealed that mathematical self-efficacy was significantly different between the groups as the adult learners scored significantly lower (M = 29.38, SD = 0.61, 95% CI [28.18, 30.59]) compared to the traditional students (M = 32.87, SD = 1.04, 95% CI [30.82, 34.93]). There was no significant difference between the groups for anxiety or self-concept (Jameson & Fusco, 2014).

Motivation. Motivation is defined as the natural human ability to direct energy towards a goal (Ginsberg & Wlodkowski, 2009). Motivation is essential to the learning processes, as students with high levels of motivation are more engaged in the learning process (Usher & Pajares, 2009). Additionally, students who exhibit greater motivation will generally experience better academic outcomes (George, 2010). Student motivation and efforts to learn lead to increased levels of mastery (Usher & Pajares, 2009). Motivation is comprised of two goal orientations, intrinsic and extrinsic. With intrinsic motivation, students are willfully engaged in an activity and find enjoyment in the process, whereas extrinsic goal orientation has been connected to negative outcomes (Stevens, Olivarez, Lan, & Talent-Runnels, 2004).

Motivational orientations are possibly linked to mathematics achievement, as enjoyment is connected to greater participation in mathematical concepts (Stevens et al., 2004). One facet of developmental mathematics is to provide underprepared students with the skills and motivation for success in college-level mathematics courses (Jameson & Fusco, 2014). Developing lessons that are collaborative and engaging allows the students to be intrinsically motivated (Ginsberg & Wlodkowski, 2009), which is interconnected with one of the core principles of Knowles's (1974) adult learning theory. Support of intrinsic motivation requires attention and focus on the needs of the students

and incorporating relevance (Reeve, Ryan, Deci, & Jang, 2008).

Self-regulation. Bandura (1994) described self-regulation as the ability to exert control over one's own motivation, emotions, behavior, and thought processes. Zimmerman (2008) described self-regulation as the process in which individuals set a goal, perform the required task, and reflect on the outcome. Later ideas developed for focusing on the process of self-regulation to improve student outcomes (Zimmerman, 2008). Research on these processes has revealed the difference between good and poor self-regulation, with the use of good self-regulation resulting in setting better goals, better learning strategies, and better monitoring (Zimmerman & Schunk, 2008). In terms of self-regulated learning, research has shown that motivational processes are vitally important to the initiation, guidance, and sustainment to self-regulate (Zimmerman & Schunk, 2008).

Pajares (2008) found that students who possess high levels of self-efficacy were more effective in the use of self-regulation. In addition, research shows that the mathematics self-efficacy of these students was positively correlated to self-regulation strategies (Pajares, 2008). Developmental mathematics courses assist students with developing a greater sense of self-regulation through independent and contextualized learning activities (Bettinger et al., 2013). Zimmerman (2008) posited that students can enhance the motivational process for learning through high quality self-regulation. Using Knowles's (1974) principles of adult learning, educators in developmental mathematics programs can apply these principles to assist adult learners in being successful in subsequent college-level mathematics courses. In addition, these principles are used to develop the learning activities to be included in the developmental mathematics courses

to increase the success of underprepared students.

External Factors on Student Persistence in a Program

Student retention is viewed from the standpoint of the institution, to retain the student; however, students want to persist (Tinto, 2017). Persistence is the process or act of continuing towards attaining an educational goal (U.S. Department of Education, National Center for Education Statistics, 1997). Persistence is also defined, for adult learners, as staying in educational programs until they reach their educational goal (Comings, 2007). The principles of the adult learning theory (Knowles, 1974) are key characteristics for assisting adult learners to persist in the mathematics program. In the social integration framework, Tinto (1993) declared that integration into the social and academic life of the college leads to the student remaining in the institution. Academic integration into the college life is accomplished through student involvement in the academic activities, whereas social integration results from the creation of relationships outside of the classroom and social activities (Tinto, 1993; Karp et al., 2011). Students enter higher education with characteristics that could influence persistence such as personal attributes, family background and community characteristics, skills, financial resources, dispositions, and precollege academic experiences (Stewart, Lim, & Kim, 2015; Tinto, 1975).

Tinto (2017) described persistence as a form of motivation molded by the experiences and perceptions of students. As a motivational factor, persistence is influenced by three factors central to students: self-efficacy, sense of belonging, and perception of the curriculum (Tinto, 2016).

Self-efficacy. Bandura (1994) termed self-efficacy as the belief in one's ability to

be successful or accomplish a task. Having a high self-efficacy promotes goal attainment, more exertion towards a goal, and extended engagement or persistence in a task (Bandura 1994). In contrast, a low self-efficacy leads to lack of persistence or exertion to accomplish a task or reach a goal Bandura (1994). Self-efficacy of college students is very important to the students' belief in the ability to succeed and persist to completion (DeWitz, Woolsey, & Walsh, 2009; Tinto, 2017). Students' failure to believe in their ability to succeed could lead to discouragement and possible withdrawal, even if the student is capable of academic attainment (Tinto, 2017). It is then understood that the ability to succeed does not guarantee success.

Goals. The development of a goal for attending and completing college is necessary for beginning the process of completing college (Tinto, 2017); however, student goals for attending the same or different institution vary, which in turn can influence motivation (Tinto, 2017). Motivation is comprised of both intrinsic and extrinsic goal orientations. Some students attend college for the intrinsic benefits such as learning, personal development, autonomy, and organizational affiliations (Tinto, 2017). Others attend college for the extrinsic benefits such as income, academic attainment, and occupation/career (Tinto, 2017). One principle of adult learners is motivation (Knowles, 1974; Knowles et al., 2005). These students are internally motivated to pursue their educational goals. Student goals are important, as the goals and motivation for attending college can be affected by life's experiences for completion or persistence (Tinto, 2017).

Sense of belonging. Belief in one's ability to successfully complete a task does not guarantee persistence for completing the task (Tinto, 2017). One requirement for a sense of belonging is for students to feel they are a valued part of the college, a member

of the group, and that they matter (Tinto, 2017). Increasing the sense of belonging results in academic integration with the college which leads to an increased chance for persistence (Tinto, 1975). In this process, a bond and a commitment to the academic community is formed to sustain the relationship even through challenges (Tinto, 1987).

The development of common interests with other students is beneficial to the student; however, developing common interests with the institution has more effect on the student's motivation for persistence (Tinto, 2017). Student perceptions of engagement with and within the institution enhance the sense of belonging which in turn enhances the motivation for engagement and thereby increases persistence (Tinto, 2017); however, a student who does not experience that sense of belonging with an institution is likely to withdraw or drop out (Tinto 2017). As such, developmental mathematics programs were designed with principles of adult learning theory for relevance, internal motivation, and the desire for knowledge by incorporating contextualized, self-directed, and motivational learning activities in the curriculum.

Perceptions of curriculum. Student perceptions of the relevance and value of education can play a role in the students' motivation to persist (Tinto, 2017). For students attending a specific college, student perceptions are influenced by curriculum quality and application to their life (Tinto, 2017). When examining the curriculum, student perceptions of the quality of both the college and curriculum, relevance, instructional methods, and personal preferences are key to persistence (Tinto, 2017). According to Knowles (1974), relevance is one of the core principles of adult learning. Adult learners have a need to be involved in the learning process and develop understanding of how knowledge applies to their life (Kenner & Wienerman, 2011). As

the curriculum portrays the values of the institution, students must consider whether the perceived curriculum is worth their time and effort (Tinto, 2017). Clear understanding of the college and the curriculum serves to motivate the student to enroll, engage, and persist. By contrast, student perceptions that the curriculum is not worth the time or is of low quality could influence the motivation to persist (Tinto, 2017).

Given these factors for persistence, institutions should consider the students' self-efficacy by providing interventions or academic support. In consideration of the students' sense of belonging, colleges can improve student-faculty interactions and increase opportunities for engagement and student perceptions of the curriculum to increase the likelihood that students persist within that institution (Tinto, 2017).

Though Tinto (2017) posited that self-efficacy, sense of belonging, and perceptions of curriculum are the factors affecting persistence, the list presented here is not conclusive. Research related to the persistence of students has generated other factors for examination of the effect on student persistence.

Research shows that for first-generation students, lack of parental knowledge regarding higher education continues to be a barrier and poses a risk to the persistence of these students (Cataldi, Bennett, & Chen, 2018). The data for this research study were collected from three sources with different perspectives of a distinct group of first-generation students (Cataldi et al., 2018). The study of first-generation students was developed to answer three questions; however, only the second questions are applicable to the topic of underprepared students. The question posed for research purposes is, "Compared with students whose parents attended at least some college, how do first-generation students fare after enrolling in postsecondary education? At what rates do

they attain degrees or certificates or remain enrolled?" One key finding in the research is that 3 years after first enrolling in college, 33% of first-generation students did not persist to degree completion compared to 26% for continuing generation students (Cataldi et al., 2018).

Another research study examined the role of developmental courses as a factor in persistence (Long & Boatman, 2013). Studies using descriptive statistics suggest that the persistence rates are lower for students placed in developmental education (Bailey, 2009). Low persistence rates for developmental students is attributed to the fact that these students are academically underprepared for college (Long & Boatman, 2013). As a result of the sequential nature of the developmental curriculum, students are delayed in their progress towards a degree, become frustrated, and drop out (Long & Boatman, 2013).

An ex post facto design study integrating the student departure theory of Tinto (1993) examined the implications of developmental education placement through the lens of demographic variables to determine the extent to which developmental placement predicts persistence (Stewart et al., 2015). The variables examined in this study were family characteristics, precollege and college academic performance to determine a relationship between ACT scores, high school GPA and first semester college GPA, and persistence (Stewart et al., 2015). The data collected for the study were secondary longitudinal data from a state higher education database. The participants in the study were full-time, first time freshman between the ages of 17 and 21 enrolled during the fall 2006-fall 2008 semesters. The research was conducted using ANOVA, Pearson's product-moment correlations, and multiple regression analysis (Stewart et al., 2015).

Findings from the study were 60.5% of developmental students persisted for five or more semesters, whereas 39.5% of developmental students persisted for four or less semesters. Additionally, data analysis revealed that students who did not enroll in developmental courses were more likely to persist than students placed in developmental courses, mean scores of 4.69 and 4.49 respectively (Stewart et al., 2015).

Persistence in the mathematics program is central to adult learners reaching their educational goals. To assist these learners, the principles of the adult learning theory are incorporated into the developmental mathematics program (Comings, 2007). Integrating adult learners into the college fosters the sense of belonging necessary for these students to persist (Deli-Amen, 2011; Tinto, 2017). In addition, developing a high self-efficacy helps adult learners to persist in the mathematics program (Bandura, 1994).

Conclusion

The process of redesigning developmental mathematics courses into modules has been completed in SCCS; however, even with the completion of the redesign, there are still many variables to be considered for reform. As the instructional delivery method was delegated to each community college, an overall understanding of the best practices is an area for ongoing research. Specifically, conversations are needed regarding the students who will be in the developmental mathematics program. Under the Multiple Measures policy, the face of developmental mathematics is changing (Boylan et al., 2017). Many of the traditional students are bypassing developmental education. For students in these classes to experience success, instructors will continue to contextualize the concepts and adopt teaching strategies to ensure the students are prepared for subsequent college-level mathematics courses (Perin, 2011).

It is important to develop an understanding of the underprepared students in developmental mathematics to assist these students with progressing through the modules, to enroll in college-level mathematics courses, and to persist to graduation (Boylan et al., 2017). Several external factors related to the success and persistence of students are described in this study; however, it is not a comprehensive list. Constant review of the characteristics of students in developmental mathematics and strategies for success and persistence are necessary.

Chapter 3: Methodology

Over the last few decades, there has been an increase in the number of students entering community colleges unprepared for college-level coursework (Bailey et al., 2010). Many of these students enroll in developmental education, specifically developmental mathematics. Unfortunately, many of these underprepared students do not complete the course sequences or continue to college-level coursework for various reasons (Boylan et al., 2017). This study is a nonexperimental correlational research design. Creswell (2014) described the correlational research design as one in which the researcher uses a correlational statistic for measuring the relationship between two or more variables. This study sought to answer questions related to the relationship between developmental mathematics and the success of underprepared students in subsequent college-level or gateway mathematics courses. For the purpose of this study, student success is defined as a grade of C or better. This study also examined the relationship between students taking developmental mathematics and persistence in the mathematics program. Persistence in the program is defined as continued enrollment in consecutive semesters in the community college within a program of study (Luke et al., 2014). The remainder of the chapter contains a description of the participants, research design, research questions, procedures for data collection, and data analysis.

Participants

The participants in this study were students in SCCS who completed one or more developmental mathematics course and continued to complete a gateway or college-level mathematics course during the 2010-2011 and 2016-2017 academic years. These students consisted of two cohorts based on the developmental mathematics curriculum.

The first cohort (traditional cohort) of students included students who enrolled in developmental mathematics during the 16-week course curriculum in 2009-2010. The data collected for the participants were used to compare the performance (success and persistence) of the two cohorts. The second cohort (redesign cohort) of students included students who were enrolled in developmental mathematics during the 4-week modules in 2015-2016. The data collected for this cohort were used to determine success in subsequent college-level mathematics courses and persistence in the mathematics program. Within these two cohorts, three subgroups of participants were examined: minority (Hispanic and Black), low-income, and nontraditional (over the age of 24) students. The number of participants in the subgroups was established with the data collected from the state system. Academically underprepared students are students who are considered first generation college students, minorities, over the age of 24, and/or from low-income families (Boylan & Trawick, 2015). Using the scope of the characteristics of underprepared students, this study focused on the success and persistence of these students.

The population for this study included students enrolled in developmental mathematics courses on community college campuses in SCCS. During the 2009-2010 academic year, there were approximately 83,040 students enrolled in the developmental mathematics courses. Demographical characteristics for the students enrolled in developmental mathematics for the 2009-2010 academic year are presented in Figure 2. Additionally, there were 41,252 nontraditional students and 52,708 low-income students enrolled in developmental mathematics in the 2009-2010 academic year.

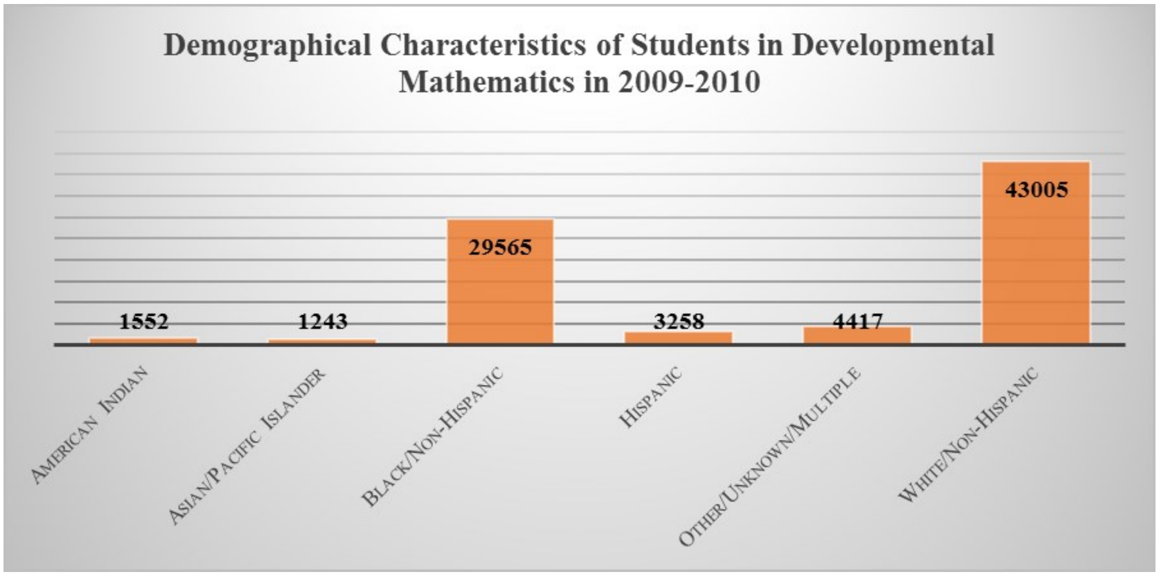

Figure 2. Demographical Characteristics of Students in Developmental Mathematics for 2009-2010.

The participants in the first cohort (traditional cohort) included the students who were enrolled in developmental mathematics during the 2009-2010 academic year, in which approximately 16,555 of these students completed college-level mathematics courses during the 2010-2011 academic year. Data collection was focused on the following student subgroups: minority (Black and Hispanic), nontraditional (over the age of 24), and low income (Pell Grant recipient). The second cohort (redesign cohort) of participants in this study included the same subgroups of students, only these students were enrolled in developmental mathematics during the 2015-2016 academic year. Approximately 7,847 of these students completed college-level mathematics courses during the 2016-2017 academic year. This year was the fifth academic year of the redesigned curriculum. The subgroups of these students examined for this research study were minority (Black and Hispanic), nontraditional (over the age of 24), and low income (Pell Grant recipient). The demographical characteristics of the students enrolled in

developmental mathematics during 2015-2016 academic year are shown in Figure 3. In addition, there were 16,613 nontraditional students and 25,072 low-income students enrolled in developmental mathematics in 2015-2016.

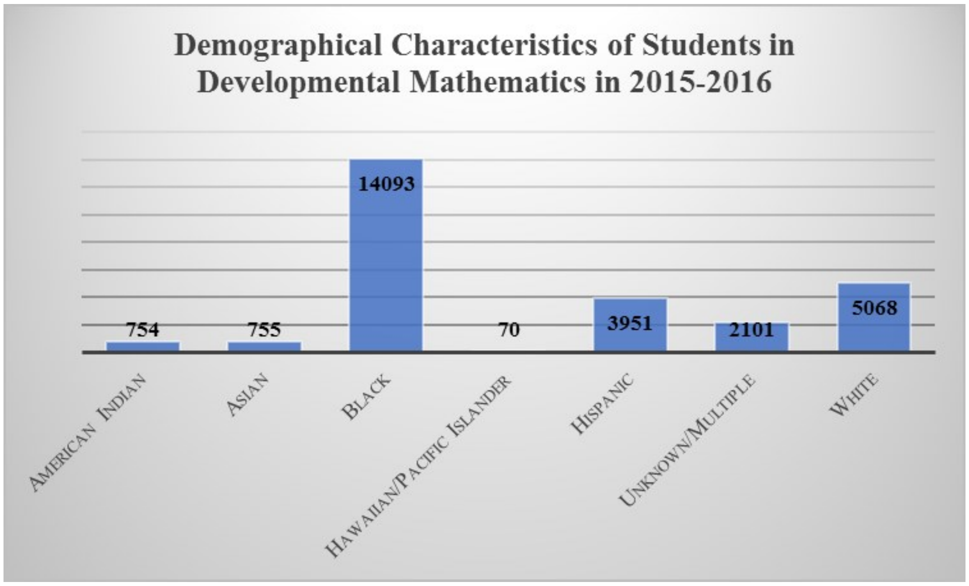

Figure 3. Demographical Characteristics of Students in Developmental Mathematics for 2015-2016.

Table 2 shows the number and percentages (of total students) of participants in each of these targeted subgroups who completed college-level mathematics in 2010-2011 and in 2016-2017.

Table 2

Participant Subgroups in College-Level Mathematics in 2010-2011 and 2016-2017

Subgroups	Number (2010-2011) (%)	Number (2016-2017) (%)
Black or African American	4,235 (25.6%)	2,053 (26.16%)
Hispanic	723 (4.4%)	916 (11.67%)
Nontraditional	7,967 (48.1%)	2,681 (34.17%)
Low Income	9,762 (59.0%)	4,490 (57.22%)
Total Students	16,555	7,847

The number of students enrolled in developmental mathematics in the 2015-2016 academic year declined to approximately 39,299 students. Some of the decline in enrollment was attributed to the redesign of the curriculum in 2011 and the implementation of Multiple Measures as students bypassed developmental mathematics.

Research Design and Rationale

This study was a nonexperimental correlational research study. A correlational study is comprised of data collected for examination of the existence of a relationship and the degree of the relationship between two or more quantifiable variables (Gay, Mills, & Airasian, 2012). In this study, the variables were categorical, with the dependent variables of success and persistence. The odds ratio (2x2) was used to predict the likelihood for an observation to fall into one of two dichotomous categorical dependent variables based on one or more categorical independent variables (Laerd Statistics, n.d.). Statistical methods consisted of the chi-square test of independence to determine if there was a correlation between the demographical characteristics of students in developmental mathematics courses and student persistence in the program as well as examining if there was a correlation between these characteristics of students in developmental mathematics and success in subsequent college-level mathematics courses. The Cramer's V test and Phi coefficient was used to determine the strength of the association between the variables. The research questions that guided this study were

1. What is the correlation between the characteristics of underprepared students in developmental mathematics and success in subsequent college-level mathematics courses?
2. What is the correlation between the characteristics of underprepared students

in developmental mathematics and persistence in the mathematics program?

3. How does the performance of underprepared students in subsequent college-level mathematics courses and persistence compare for students completing the traditional or redesigned developmental mathematics course sequences?

Developmental mathematics data, collected from the SCCS data warehouse for this research study, were used to determine the correlation between the dependent variable of student success (as determined by a grade of C or better) in subsequent college-level mathematics courses and the independent variables of nontraditional (over the age of 24), minority (Black and Hispanic), and low income. Student success in these courses was examined for students who were enrolled in the 16-week developmental mathematics courses (traditional cohort) compared to the 4-week developmental mathematics courses (redesign cohort). This research study also examined the correlation between the dependent variable, persistence of students who completed developmental mathematics (16 weeks versus 4 weeks), and the independent variables: nontraditional (over the age of 24), minority (Black and Hispanic), and low income. The findings may be used to inform some community colleges on the success of developmental mathematics students in college-level mathematics courses prior to implementation of the reformed model for developmental mathematics. Such information may also be used to guide the content of the corequisite courses for the upcoming reform of the developmental mathematics program.

Procedures

This study encompassed a collection of quantitative data obtained through the SCCS data warehouse. The data were collected by SCCS for use in developing the

performance measures for each community college. Upon approval of the dissertation committee and completion of the Internal Review Board (IRB) process for Gardner-Webb University, the SCCS office was notified. At completion, SCCS received a request for disaggregated data on students who completed a college-level mathematics course within 1 year of successfully completing the developmental mathematics sequence (Appendix A). Upon receipt of the request, the researcher was notified that the data would be in the form of frequencies for each category of the variables, with the total number of students.

Data were collected for the last year of the traditional developmental mathematics sequence (2010-2011) and the fifth full year of the redesigned curriculum (2016-2017). Data gathered on the participants had no identifying markers. These data from the state data warehouse for the community college system were grouped with grades, low income (Pell/no Pell), nontraditional and traditional, and enrollment data into a gateway mathematics or developmental mathematics course. Success was determined as a grade of C or better for each of the subgroups of minorities (Black and Hispanic), low-income, and nontraditional (over the age of 24) students. Additionally, enrollment data for continuous enrollment (within 1 year) in either the next developmental mathematics course or the gateway mathematics course were collected for analysis. Data were cleaned to ensure there was no missing data. Students without grades were included for enrollment purposes, though neither a success nor failure was included in the data set for grades. The data were then analyzed for a correlation between demographical characteristics of students in developmental mathematics and success and persistence using the chi-square test of independence.

Data Analysis

The quantitative data analysis was completed using chi-square analysis of the data. This test was used as there are three nominal independent variables and one dichotomous dependent variable. The independent variables for analysis were the characteristics of underprepared students: minority (Black and Hispanic), nontraditional (over the age of 24) and low income. The dependent variables were the determination of the students' continued enrollment in either developmental mathematics or a gateway mathematics course (persistence) and the grades for student success as determined by a grade of C or better in subsequent college-level mathematics courses. The chi-square test of independence is a type of analysis in which the independent variables and a dichotomous dependent variable are placed into 2x2 contingency tables. In addition, a 2x4 contingency table was used to answer the third research question. These tables were completed for each research question. Data analysis using the chi-square test encompassed the observed (actual) and the expected values for the dichotomous dependent variable.

The chi-square test of independence was used to examine the relationship between the independent variables of minority (Black and Hispanic), low income, and nontraditional (over the age of 24) and the dependent variables of success and persistence in the mathematics program. For any statistically significant relationships between the variables, the Cramer's V test and the Phi coefficient were used to determine the strength of association between the variables using effect size for the 2x4 and the 2x2 contingency tables respectively. The effect size is used to measure the observed effect of a statistic by reducing the size of the impact (Urdan, 2017). Cramer's V test statistic ranges between 0

and 1, with 0 showing no association and 1 showing complete association. The interpretation for Cramer's V is shown in Figure 4.

Magnitude of effect size	Value of Cramer's V
Small	0.1
Medium (Moderate)	0.3
Large	0.5

Figure 4. Effect Size for Interpretation of Cramer's V.

After using chi-square test of independence for the 2x2 contingency tables, Phi was used to determine the strength of the association between variables. Phi coefficient ranges between -1 and 1, similar to the correlation coefficient, and is interpreted in a similar manner with no regard to the sign. The Phi coefficient correlation represents the types of association ranging from strong to very weak as determined by the Phi value. Table 3 shows the Phi coefficient value representations.

Table 3

Phi Coefficient Value Representations

Phi Value	Strength of Association
-1 to -0.5 or 0.5 to 1	Strong Association
-0.5 to 0.3 or 0.3 to 0.5	Moderate Association
-0.3 to -0.1 or 0.1 to 0.3	Weak Association
-0.1 to 0.1	Very Weak or No Association

The odds ratio is the probability of the event occurring (p) divided by the probability of the event not occurring (1-p). The calculation of the odds ratio was used to determine the likelihood of the event relative to each research question (Laerd Statistics,

n.d.). With the chi-square test of homogeneity, statistically significant differences in the proportion were examined using a post hoc test. The chi-square goodness of fit test was used to make pairwise comparisons for Bonferroni corrections. Bonferroni corrections is an adjustment for p values to determine for which pair of variables there is a statistically significant difference in the proportions. Research questions and data analyses are presented in Table 4.

Table 4

Research Questions and Data Analysis

Research Question	Independent Variables	Dependent Variable	Data Collected	Data Analysis
1. What is the correlation between the characteristics of underprepared students in developmental mathematics and success in in subsequent college-level mathematics courses?	Low income Minority Nontraditional	Success	Grades in subsequent college-level mathematics courses, A, B, C – success D, F, W, OW – failure	Chi-square test of independence, p < .05 statistically significant (not independent) Phi coefficient for strength of association, Odds Ratio
2. What is the correlation between developmental mathematics and the persistence of academically underprepared students?	Low income Minority Nontraditional	Persistence	Enrollment data in developmental mathematics or subsequent college level mathematics	Chi-square test of independence, p < .05 statistically significant (not independent) Phi coefficient for strength of association, Odds Ratio
3. How does the performance of underprepared students in subsequent college-level mathematics courses and persistence compare for students completing the traditional or redesigned developmental mathematics course sequence?	Low income Minority Nontraditional	Success Persistence	Grades in subsequent college-level mathematics courses, A, B, C – success D, F, W, OW – failure Enrollment data in developmental mathematics or subsequent college level mathematics	Test of two proportions-%, chi-square test of significance, Cramer's V, p < .05, Bonferroni corrections with adjusted p values for both dependent variables

Limitations of the Study

There were several limitations to this study. The first limitation was to include only the students who were enrolled in the developmental mathematics program in the

2009-2010 academic year, the year prior to the 2010-2011 year of the traditional model. In addition, only students enrolled in the developmental mathematics program in the 2015-2016 academic year for the 2016-2017 year of the redesigned model were included. A second limitation of the research study was to include only students who continued in the course sequence to complete a college-level or gateway mathematics course for success as determined by a grade of C or better or failure. All other grades such as D, F, W (withdrawal), and O (official withdrawal) were considered failing grades. Third, the enrollment data for students who did not continue to remain enrolled after taking developmental mathematics were used to determine a correlation between developmental mathematics and student persistence. Fourth, the participants for this study were representative of SCCS and may not be generalizable to any one community college. Additionally, the results of this study were representative of SCCS and may not be generalizable to other community college systems. A fifth limitation is the examination of the developmental mathematics course and does not distinguish for any of the effects of other supports provided by developmental education. In addition to these limitations, there was a limitation for low-income students, as some students did not receive the Pell Grant, though the student/s qualified to receive the Pell Grant.

Delimitations

There were several delimitations associated with this research study. The first delimitation was the years chosen in which to gather data for the participants. This study only included the last year of the traditional 16-week curriculum prior to the redesign and the fifth full year of the redesigned 4-week modules after full implementation of Multiple Measures. The second delimitation was to change the methodology of the study from

logistic regression to chi-square tests of independence and the chi-square test of homogeneity. The change in data analysis was based on the format of the data collected for the participants in the study. The third delimitation of this study was to delete the independent variable of first generation from the analysis, as SCCS did not have a method of determination of this status.

Threats to Validity

Ethical procedures for this study were completed early in the process as several community colleges were approached for interest in the completion of the study at the site (Appendices B and C). Prior to collecting data, an IRB with Gardner-Webb University was completed to request access to the data for the students enrolled in developmental mathematics and subsequent college-level mathematics courses. Possible threats to the internal validity of this research study, selection and mortality, were minimized by random selection of a large group of participants. Possible external threats to the study were minimized by including limitations to the generalizability of this study. There were no identifying markers on the data, and there was no risk to the participants.

Summary

This chapter contained an introduction of the purpose of this study which was to determine the existence of a relationship between the demographical characteristics of students in developmental mathematics and student persistence and success. The setting for the research study was SCCS. The participants in the study were those students enrolled in one, two, three, or more developmental mathematics courses who continued to a subsequent college-level mathematics course. The study design was a nonexperimental correlational research design. Data for student grades and enrollment in

developmental mathematics and college-level mathematics courses were gathered to determine the correlation between demographical characteristics of underprepared students and success and persistence.

Chapter 4: Results

Introduction

With the increased number of underprepared students entering community colleges, student success and persistence continue to be important factors for college completion on the community college campuses in SCCS (Boylan et al., 2017). Underprepared students are defined as students who are required to take at least one developmental education course prior to enrolling in curriculum level coursework (Schak et al., 2017). These students are enrolling in developmental mathematics courses; however, for many, completing the course sequence continues to be an issue (Stern, 2012). SCCS became very concerned with the plight of the developmental students. By completing listening tours across the state, the data revealed that only 8% of the students enrolling in the developmental mathematics course sequences were finishing the sequence to enroll in college-level mathematics courses (Brown & Spies, 2015). With such evidence, the community college system implemented a redesign of the developmental education program in 2011. The state developmental education redesign resulted in a change from the traditional 16-week courses to eight 4-week modules for the developmental mathematics sequence.

Several factors affecting student success and persistence in the mathematics program were presented in this study. The purpose of this study was to analyze the relationship between the demographical characteristics of developmental mathematics students and success in subsequent college-level mathematics courses. Additionally, the study analyzed the relationship between the demographical characteristics of developmental mathematics students and persistence in the mathematics program.

Student success in college-level mathematics courses was also compared for students in the previous 16-week (traditional) curriculum and the redesigned 4-week modules. As such, this chapter presents the data analysis and the results along with the research questions.

The data collected were obtained from SCCS. The data encompassed the 2009-2010 and 2015-2016 academic years of students enrolled in developmental mathematics for analysis of persistence. In addition, data for the students enrolled in college-level mathematics and developmental mathematics during the 2010-2011 and 2016-2017 academic years were obtained for analysis of student success. The community college system is currently in the sixth year of the redesigned curriculum with an upcoming reform of the developmental education program.

Research Questions

There were three research questions guiding the research study. These research questions focused on demographical characteristics of underprepared students and success and persistence. These questions were

1. What is the correlation between the characteristics of underprepared students in developmental mathematics and success in subsequent college-level mathematics courses?
2. What is the correlation between the characteristics of underprepared students in developmental mathematics and persistence in the mathematics program?
3. How does the performance of underprepared students in subsequent college-level mathematics courses and persistence compare for students completing the traditional or redesigned developmental mathematics course sequences?

The chi-square test of independence was used to examine the relationship between the demographical characteristics of developmental mathematics students and success in subsequent college-level mathematics course and persistence. The chi-square test of independence was conducted between each subgroup and success in college-level mathematics courses. The remainder of the chapter contains the research questions and the results.

Research Question 1. What is the correlation between the characteristics of underprepared students in developmental mathematics and success in subsequent college-level mathematics courses?

Success in Subsequent College-Level Mathematics

Student success, for the purposes of this study, was defined as a grade of C or better in a college-level mathematics course. The first research question focused on the success of students classified according to demographical characteristics of minority (Black or Hispanic), nontraditional (over the age of 24), and low income (Pell-Grant recipient) in subsequent college-level mathematics courses. Data were received in the form of frequencies for the number of students in either category. Each subgroup of students was divided into pass/fail according to grades. Grades of A, B, and C were considered passing, whereas, D, F, W, and O were considered failing. Table 5 shows the student grade distribution for 2016-2017 college-level mathematics courses based on previous enrollment in developmental mathematics courses.

Table 5

Grade Distributions for College-level Mathematics in 2016-2017

Subgroups	A	B	C	D	F	W
Black	237	519	543	279	416	502
Hispanic	146	253	245	104	172	209
Nontraditional	728	934	700	286	413	757
Low Income	787	1,216	1,137	516	726	1,073
Total	1,898	2,922	2,625	1,185	1,727	2,541
	Total Successes: 7,445			Total Failures: 5,453		

Note: Totals may exceed 100% of the number of students as students may have enrolled in one or more college-level mathematics course during the 2016-2017 academic year. *Grades of O are not recorded by the SCCS for credit bearing courses.

For SCCS, a grade of O has no value, as it is an official withdrawal from the course and is only recorded on the transcript. The grade distributions for the 2016-2017 academic year among the subgroups totaled 7,445 successes and 5,453 failures. Further examination of the grade distributions revealed that approximately 26% of the successes are attributable to minority (Black and Hispanic) students, whereas 42% of the failures of the subgroups are attributable to low-income students. The graphical representation of the success of underprepared students in college-level mathematics courses is presented in Figure 5.

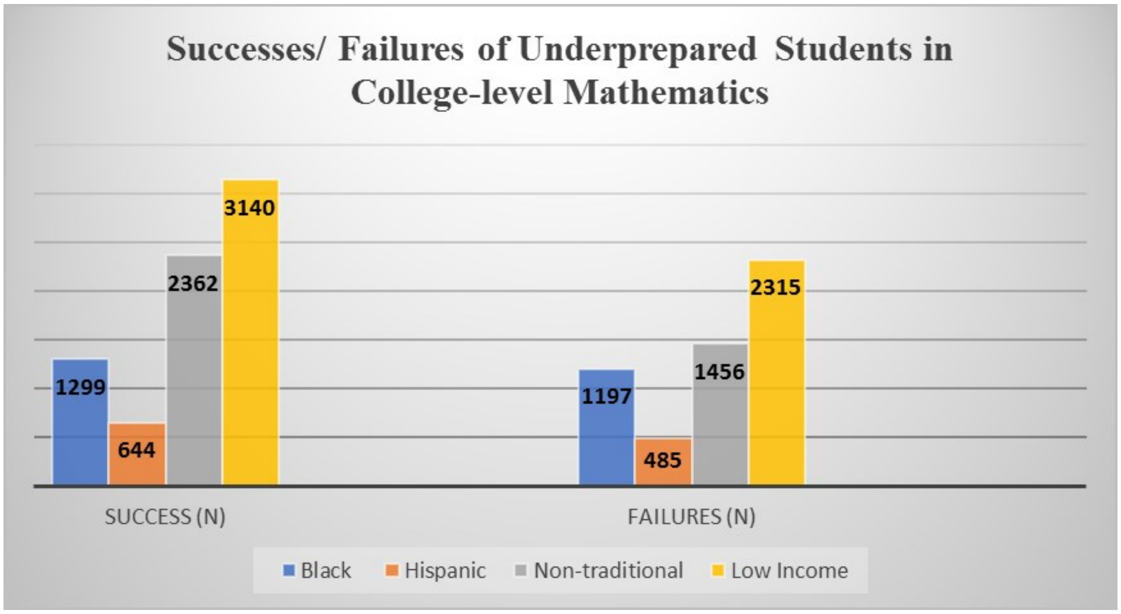

Figure 5. Success/Failures for Underprepared Students in 2016-2017.

Of the total grades for underprepared students, slightly more than 42% of the grades resulted in a failure. Percentages for low-income students for success and failure were approximately equal at 42.18% and 42.45% respectively. The success rates for low-income students (57.56%) were slightly lower than students who were not considered low income (57.97%). Data representing the success rates is presented in Table 6.

Table 6

Success Rates of Underprepared Students in College-Level Mathematics in 2016-2017

Subgroups	Success (N)	%	Failures (N)	%
Black	1,299	17.45%	1,197	21.95%
Hispanic	644	8.65%	485	8.89%
Nontraditional	2,362	31.73%	1,456	26.70%
Low Income	3,140	42.18%	2,315	42.45%

The total percentage of failing grades for minority (Black and Hispanic) students was higher at 30.84% compared to the success rate at a combined 26.10%.

Results for Research Question 1. The chi-square test of independence was

conducted between minority (Black and Hispanic) students and success (as determined by a C or better) in subsequent college-level mathematics courses. These students completed developmental mathematics in the previous academic year, 2015-2016. The failure rate of Black and Hispanic students (46.40%) was greater than non-Black/non-Hispanic students (39.76%) by about 6.64%. More than half (53.60%) of the Black and Hispanic students successfully completed a college-level or gateway mathematics course. The analysis of these two variables revealed a statistically significant ($\alpha = .05$) association between minority (Black and Hispanic) students and success in subsequent college-level mathematics courses (X^2 (1) = 40.81, $p < .00001$). Table 7 shows the results of the chi-square test for minority (Black and Hispanic) students and success in subsequent college-level mathematics courses.

Table 7

Minority (Black and Hispanic) Students and Success in College-Level Mathematics

	Success		
Subgroup	Yes	No	Total
Black and Hispanic	1,943 (53.60%)	1,682 (46.40%)	3,625
Non-Black and Non-Hispanic	3,609 (60.24%)	2,382 (39.76%)	5,991
Total	5,552 (57.74%)	4,064 (42.26%)	9,616

Note: $\alpha = .05$ for statistically significant results.

Further examination of these two variables for strength of association yielded $\varphi = +0.07$, a very weak association; however, it is noted that statistically significant results should not be concluded as a strong association. Figure 6 shows a graphical representation for the percentage of success for minority (Black and Hispanic) students versus non-Black/non-Hispanic students.

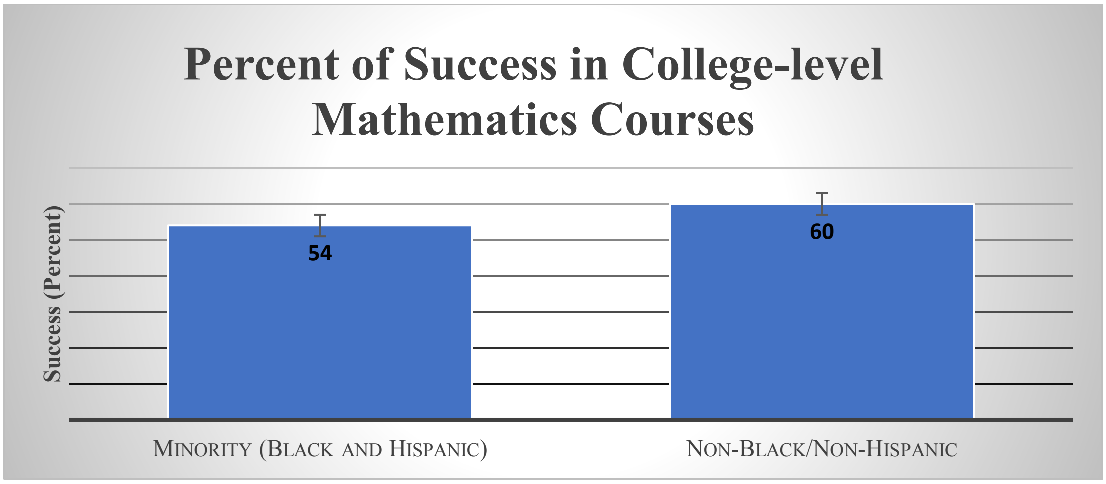

Figure 6. Comparison of Success Rates for Minority and Nonminority Students.

Additionally, the odds ratio was calculated for these two variables to provide further clarification of the results. The odds ratio, for a 2x2 contingency table, was used to predict the likelihood for an observation to fall into one of two dichotomous categorical dependent variables based on one or more categorical independent variables (Laerd Statistics, n.d.). The odds ratio calculation showed that minority (Black and Hispanic) students were less likely to be successful in college-level mathematics courses or 1.31 times more likely to experience failure in subsequent college-level mathematics course.

Nontraditional Students and Success in College-Level Mathematics

In addition, to answer the first research question, a chi-square test of independence was conducted between nontraditional (over the age of 24) students and success (as determined by a C or better) in a gateway or college-level mathematics course. These students completed developmental mathematics in the previous academic year, 2015-2016. The results of the findings of data analysis revealed that more than 60% of nontraditional students successfully completed a college-level or gateway

mathematics course. The failure rate for nontraditional students was lower at 38.14% compared to traditional students at approximately 55.02% by 6.84%. Completion of the analysis of these two variables revealed a statistically significant ($\alpha = .05$) association between nontraditional (over the age of 24) students and success in subsequent college-level mathematics courses (X^2 (1) = 44.21, $p < .00001$). Table 8 shows the results of the chi-square test for nontraditional students and success in college-level mathematics courses.

Table 8

Nontraditional Students and Success in College-Level Mathematics

	Success		
Subgroup	Yes	No	Total
Nontraditional	2,362 (61.86%)	1,456 (38.14%)	3,818
Traditional	3,190 (55.02%)	2,608 (44.98%)	5,798
Total	5,552 (57.74%)	4,064 (42.26%)	9,616

Note: $\alpha = .05$ for statistically significant results.

Additional analysis of these two variables for strength of association yielded $\varphi =$ -0.07, a very weak association. Further analysis included the odds ratio which revealed that nontraditional (over the age of 24) students were 1.33 times more likely to be successful in subsequent college-level mathematics courses. Figure 7 shows a graphical representation of the success rates for nontraditional students versus traditional students.

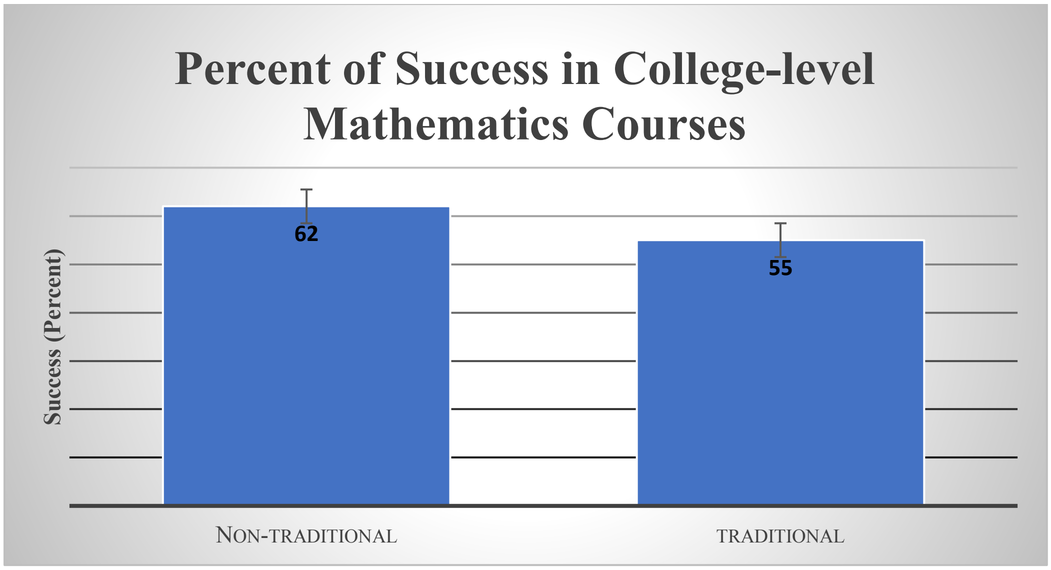

Figure 7. Comparison of Success Rates for Nontraditional and Traditional Students.

The success rate for nontraditional students was 7% higher than the success rate of traditional students.

Low-Income Students and Success in College-Level Mathematics

The chi-square test of independence was also conducted between low-income students and success in subsequent college-level mathematics courses. The chi-square analysis was done to answer the question for the correlation between the characteristics of underprepared students in developmental mathematics and success in subsequent college-level mathematics courses. As a reminder, in this study, success is determined by a grade of C or better. The students for this portion of the study were also students who completed developmental mathematics in 2015-2016. Findings were that the failure rates for low-income (Pell Grant recipient) students was only slightly higher than those who were considered non-low income (did not receive the Pell Grant) at 42.44% and 42.03% respectively. The results of the chi-square test of independence revealed that there was no statistically significant association between low-income students (Pell Grant

recipients) and success in subsequent college-level mathematics courses (X^2 (1) = 0.16, p = .689157 and φ = 0). Table 9 shows the results for the chi-square test for low-income students and success in college-level mathematics courses.

Table 9

Low-Income Students and Success in College-Level Mathematics

	Success		
Subgroup	Yes	No	Total
Low Income	3,140 (57.56%)	2,315 (42.44%)	5,455
Moderate/High Income	2,412 (57.97%)	1,749 (42.03%)	4,161
Total	5,552 (57.74%)	4,064 (42.26%)	9,616

Note: α = .05 for statistically significant results.

The odds ratio for these variables was 1.02, showing that the odds for success or failure are close to equally likely. Figure 8 depicts a graphical representation for the success rates of low-income students and students who were not considered low income.

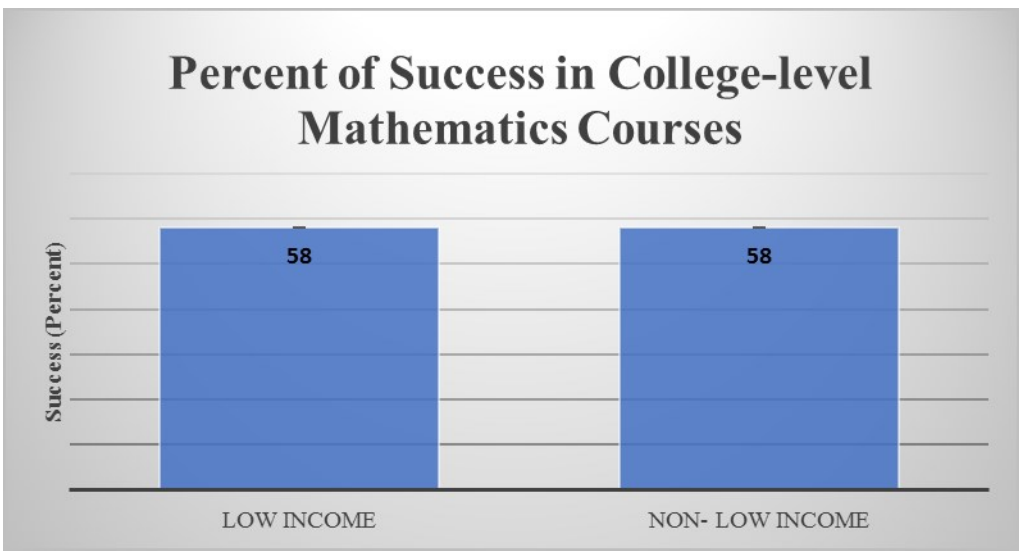

Figure 8. Comparison of Success Rates for Low-Income and Non-Low-Income Students.

The success rates for low-income students (57.56%) was only slightly lower than students who were not considered to be low income (57.97%).

Research Question 2. What is the correlation between the characteristics of underprepared students in developmental mathematics and persistence in the mathematics program?

Persistence in the Mathematics Program

Persistence in this study is defined as continued enrollment in the mathematics program. The participants in this study were enrolled in developmental mathematics in the 2015-2016 academic year. Persistence in the mathematics program is determined by enrollment within 1 year in a developmental mathematics course or a college-level mathematics course. There were 39,299 students enrolled in developmental mathematics in the 2015-2016 academic year. Of these students, 15,088 students were enrolled in developmental mathematics or college-level mathematics during the 2016-2017 academic year. Figure 9 shows the demographical characteristics of students enrolled in developmental mathematics or college-level mathematics in the 2015-2016 and 2016-2017 academic years.

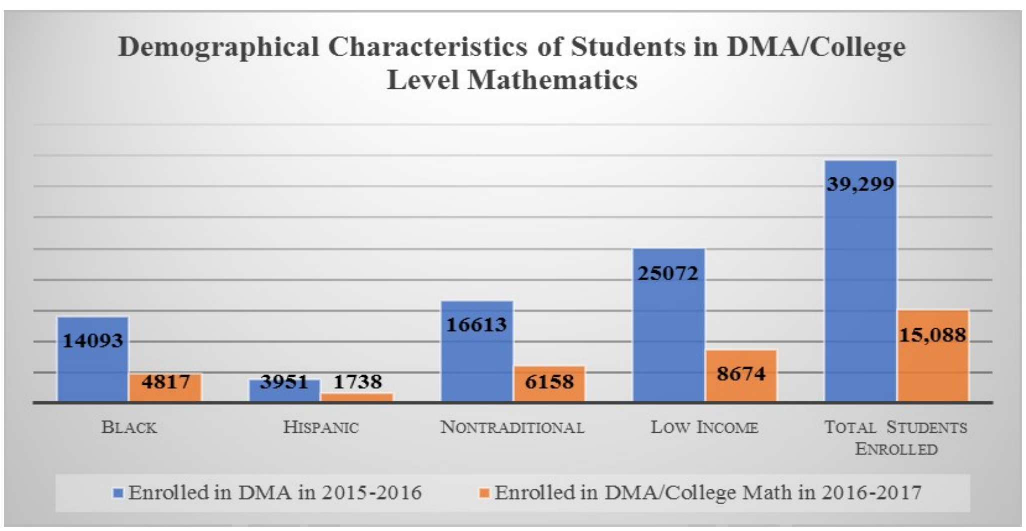

Figure 9. Demographics for Students Enrolled in Developmental Mathematics or College-Level Mathematics.

Examination of the data shows that more than 60% of the students enrolled in the developmental mathematics program in 2015-2016 were considered low income. Additionally, more than 50% of the students enrolled in either developmental mathematics or college-level mathematics in the 2016-2017 academic year were considered low income. The minority (Black and Hispanic) students comprised approximately 43% of the students enrolled in the mathematics program in the 2016-2017 academic year, which was slightly less, at 2.46%, than the number of minority (Black and Hispanic) students enrolled in the mathematics program in the previous academic year, 2015-2016. Also noted was the approximate 62% drop in enrollment from the 2015-2016 to 2016-2017 academic year. Table 10 shows the persistence rates for students in the mathematics program.

Table 10

Persistence Rates of Underprepared Students in the Mathematics Program in 2016-2017

Subgroup	Number of Students in Developmental Mathematics in 2015-2016 (%)	Number of Students in Developmental Mathematics/College Math in 2016-2017 (%)
Black	14,093 (35.86%)	4,817 (31.93%)
Hispanic	3,951 (10.05%)	1,738 (11.52%)
Nontraditional	16,613 (42.27%)	6,158 (40.81%)
Low Income	25,072 (63.80%)	8,674 (57.49%)
Total Students Enrolled	39,299	15,088

Enrollment data were analyzed to answer the second research question for this study. The chi-square test of independence was conducted on each subgroup of students to answer the second research question.

Results for Research Question 2. The chi-square test of independence was conducted between minority (Black and Hispanic) students and persistence in the

mathematics program. Persistence was determined as enrollment into developmental mathematics or college-level mathematics within 1 year of completing developmental mathematics courses. The results for the chi-square test of independence is shown in Tables 11-13. According to the data, approximately 63% of minority (Black and Hispanic) students dropped out of the mathematics program. The persistence rate for minority (Black and Hispanic) students was 3.82% lower than the persistence rate for nonminority (Black or Hispanic) students. The analysis of these two variables revealed a statistically significant ($\alpha = .05$) association between minority (Black and Hispanic) students and persistence in the mathematics program (X^2 (1) = 60.14, $p < .00001$). Table 11 shows the results of the chi-square test for minority (Black and Hispanic) students and persistence in the mathematics program.

Table 11

Minority (Black and Hispanic) Students and Persistence in the Mathematics Program

	Persisted		
Subgroup	Yes	No	Total
Black and Hispanic	6,555 (36.33%)	11,489 (63.67%)	18,044
Non-Black and Non-Hispanic	8,533 (40.15%)	12,722 (59.85%)	21,255
Total	15,088 (38.39%)	24,211 (61.61%)	39,299

Note: $\alpha = .05$ for statistically significant results.

Further examination of these two variables for strength of association yielded $\varphi = +0.04$, a very weak association. To further analyze the data for interpretation, the odds ratio was calculated for these two variables. The odds ratio showed that minority (Black and Hispanic) students were 1.18 times less likely to persist in the mathematics program. Figure 10 shows the persistence rates between minority (Black and Hispanic) students and nonminority students in the mathematics program.

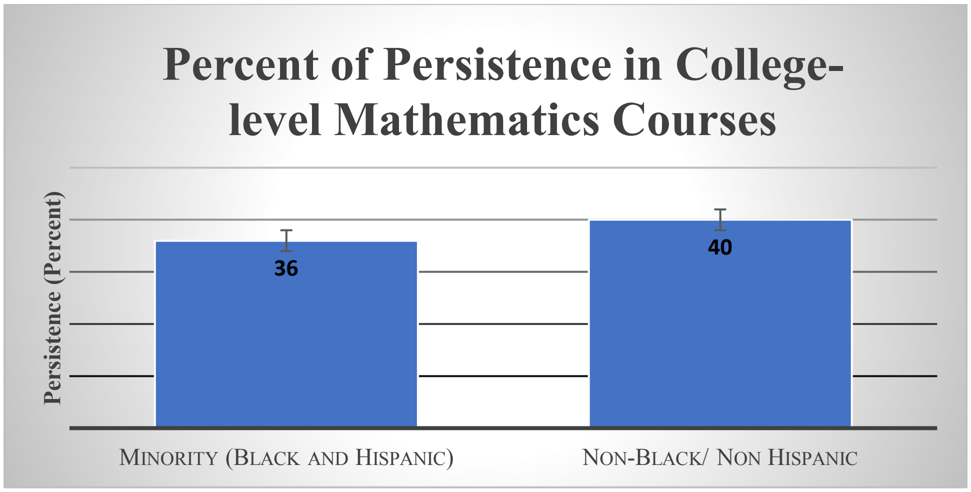

Figure 10. Comparison of Persistence Rates for Minority and Nonminority Students.

Minority (Black and Hispanic) students had a lower persistence rate of approximately 4% compared to students who were non-Black/non-Hispanic.

Nontraditional Students and Persistence in the Mathematics Program

In relation to the persistence of nontraditional students in the mathematics program, the chi-square test of independence was conducted to determine the correlation between these two variables. Analysis of the data showed that more than 60% of nontraditional students failed to continue enrollment in the mathematics program during the 2016-2017 academic year. The percentages for persistence were close for nontraditional and traditional students. The chi-square test of independence showed a statistically significant association between nontraditional students and persistence in the mathematics program (X^2 (1) = 21.38, $p < .00001$). Table 12 presents the results of the chi-square test for nontraditional students and persistence in the mathematics program.

Table 12

Nontraditional Students and Persistence in the Mathematics Program

	Persisted		
Subgroup	Yes	No	Total
Nontraditional	6,158 (37.01%)	10,455 (62.93%)	16,613
Traditional	8,930 (39.42%)	13,756 (60.64%)	22,686
Total	15,088 (38.39%)	24,211 (61.61%)	39,299

Note: α = .05 for statistically significant results.

Measurement for the strength of the association between these two variables yielded φ = +0.02, which is a very weak association. The odds ratio was also calculated for these variables and revealed that the nontraditional students are 1.10 times less likely to persist in the mathematics program. Persistence rates between nontraditional and traditional students are shown in Figure 11.

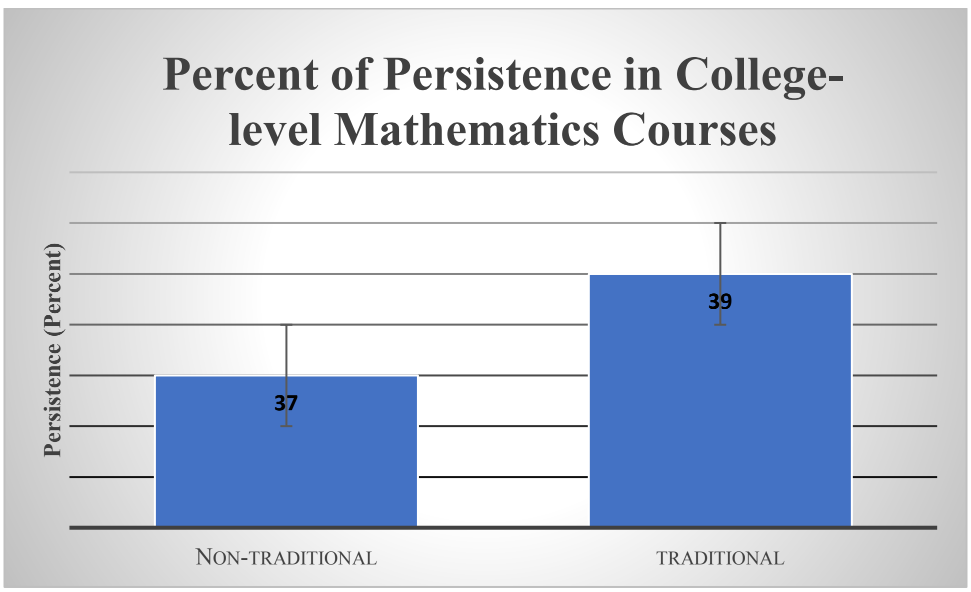

Figure 11. Comparison of Persistence Rates for Nontraditional and Traditional Students.

Data analysis revealed that approximately 2.4% fewer nontraditional students continued in the mathematics program compared to traditional students during the 2016-2017 academic year.

Low-Income Students and Persistence in the Mathematics Program

The last variables to analyze in answer to the second research question are low-income students and persistence in the mathematics program. Data collected and analyzed revealed that approximately 65% of low-income students did not persist in the mathematics program for the 2016-2017 academic year. Persistence rates for low-income students was approximately 10.48% lower than students who were not considered low income. The chi-square test of independence was conducted between low-income (Pell Grant recipient) students and persistence in the mathematics program. The results of the chi-square test showed a statistically significant association between the variables of low income and persistence in the mathematics program (X^2 (1) = 422.02, $p < .00001$) and are shown in Table 13.

Table 13

Low-Income Students and Persistence in the Mathematics Program

	Persisted		
Subgroup	Yes	No	Total
Low Income	8,674 (34.60%)	16,398 (65.40%)	25,072
Non-Low Income	6,414 (45.08%)	7,813 (54.92%)	14,227
Total	15,088 (38.39%)	24,211 (61.61%)	39,299

Note: $\alpha = .05$ for statistically significant results.

The Phi coefficient yield a result of $\varphi = +0.1$, showing a small association. The odds ratio for the likelihood of low-income students persisting in the mathematics program revealed that low-income students are 1.55 times less likely to persist in the mathematics program. A graphical representation of the percent of persistence between low-income students and students who are not considered low income is presented in Figure 12.

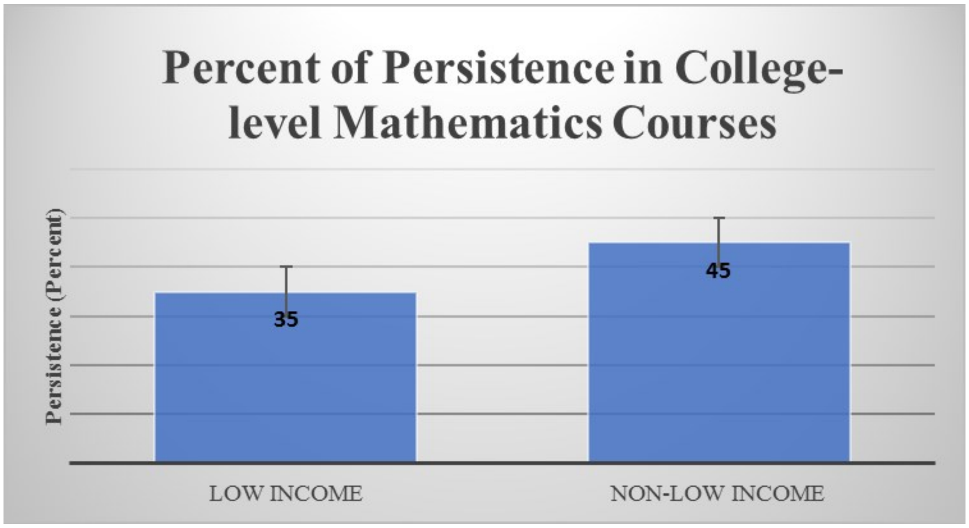

Figure 12. Comparison of Persistence Rates for Low Income and Non-Low-Income Students.

Examination of the data revealed a gap of approximately 10% between the persistence rates of low-income students and students who were not considered to be low income.

Research Question 3. How does the performance of underprepared students in subsequent college-level mathematics courses and persistence compare for students completing the traditional or redesigned developmental mathematics course sequence?

Traditional and Redesigned Developmental Mathematics Program

The final research question for this study was to compare the performance of students in college-level mathematics courses in relation to the traditional (2010-2011) curriculum and the redesigned (2016-2017) curriculum. Performance, for this study, relates to the success and persistence of these subgroups of students. As there was a redesign of the developmental mathematics program, information relating to the success and persistence of underprepared students can be pertinent to decisions regarding the curriculum. The traditional 16-week curriculum, which was redesigned in 2011,

consisted of four courses to complete the developmental mathematics sequence. The redesigned curriculum consisted of three of the four courses broken into eight 4-week modules. The participants for this research question consisted of students who completed developmental mathematics in 2009-2010 (traditional) and 2015-2016 (redesign) 1 year prior to completing a subsequent college-level mathematics course.

Results for Research Question 3. The data analyzed to answer this research question consisted of percentages of success and failures for each of the subgroups of participants for both cohorts. In addition, this research question also examined the percentages of persistence for each subgroup of the two cohorts. The test of two proportions, hereinafter referred to as the chi-square test of homogeneity, was used for analysis. The data were arranged in a 2x4 contingency table with the subgroups and analyzed for significant differences between the two proportions (Laerd Statistics, n.d.). Visual analysis of the data shows that minority (Black and Hispanic) students, collectively, experienced greater success upon completion of the redesigned developmental mathematics course sequences. Nontraditional (over the age of 24) and low-income students experienced greater success in college-level mathematics courses upon completion of the traditional developmental mathematics curriculum for the 2009-2010 academic year. Table 14 shows the successes and failures of underprepared students based upon completion of the traditional and redesigned developmental mathematics programs.

Table 14

Success/Failures of Underprepared Students in College-Level Mathematics

	2010-2011				2016-2017			
Subgroups	Success (N)	%	Failures (N)	%	Success (N)	%	Failures (N)	%
Black	3,349	19.57%	3,140	28.99%	1,299	17.45%	1,197	21.95%
Hispanic	845	4.93%	527	4.87%	644	8.65%	485	8.89%
Nontraditional	8,275	48.36%	4,271	39.44%	2,362	31.73%	1,456	26.70%
Low Income	9,615	56.19%	6,286	58.04%	3,140	42.18%	2,315	42.45%
Total	17,111		10,830		5,552		4,064	

Descriptive statistics show that Black, nontraditional, and low-income students experienced greater percentages of success upon completion of the traditional curriculum compared to the redesigned curriculum by 2.12%, 16.63%, and 14.01% respectively; however, the percentage of success was greater by 3.72% for Hispanic students in the post-redesigned curriculum. The total number of success experienced by these subgroups was 3.5% greater following the traditional curriculum. The chi-square test of homogeneity was conducted to determine if there was a statistically significant difference between the proportions of success in a college-level mathematics course for underprepared students based on completion of either the traditional or the redesigned developmental mathematics program. Success has been defined as a grade of C or better in the college-level mathematics course. These two cohorts of students completed developmental mathematics in the previous, 2009-2010 (traditional) and 2015-2016 (redesign), academic years. The analysis of these two proportions revealed a statistically significant ($\alpha = .05$) difference. The results for the chi-square test of homogeneity for each subgroup and success in college-level mathematics are presented in Table 15.

Table 15

Underprepared Students' Success and Developmental Mathematics Curriculum

	Subgroups				
Curriculum	Black	Hispanic	Nontraditional	Low-Income	Total
Traditional (Pre-Redesign)	3,349 (72.05%)	845 (56.75%)	8,275 (77.79%)	9,615 (75.38%)	22,084
Redesign	1,299 (27.95%)	644 (43.25%)	2,362 (22.21%)	3,140 (24.62%)	7,445
Total	4,648	1,489	10,637	12,755	29,529

Note: α = .05 for statistically significant results.

The two probabilities, for success in subsequent college-level mathematics courses, were not equal in the population (X^2 (3) = 328.78, $p < .00001$ and Cramer's V = .1055). Completion of the Cramer's V for effect size revealed a small association between the variables. Examination of the variables to determine which variables were associated required post hoc testing. Figure 13 provides a graphical representation for the percentage of success (of the total number of successes) for each subgroup based on the completed developmental mathematics curriculum.

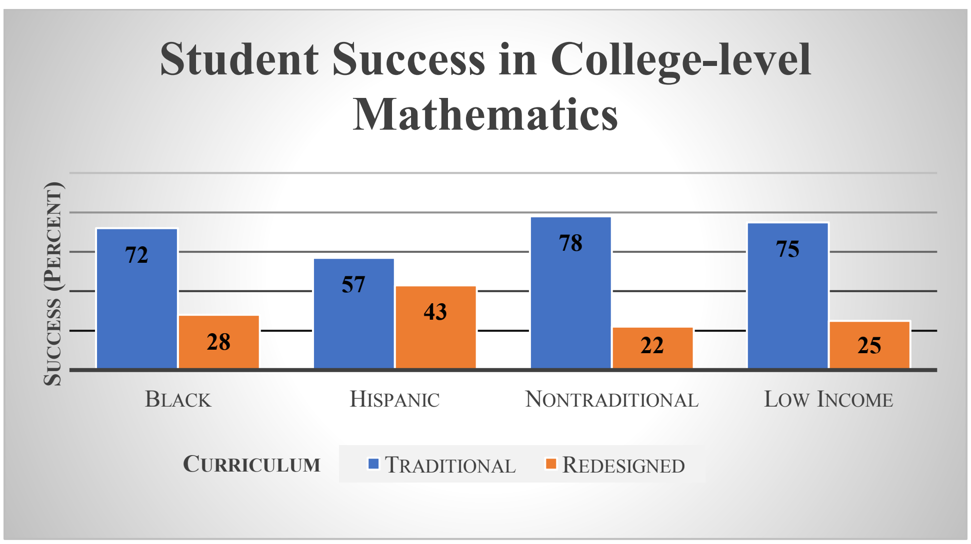

Figure 13. Success of Subgroups Based on Developmental Mathematics Curriculum.

To determine which pair of variables presented the greatest differences between

the proportions for success in college-level mathematics courses, the chi-square goodness of fit tests were completed on three pairwise comparisons to obtain the p value for each pair. The adjusted p values using Bonferroni corrections are presented in Table 16.

Table 16

Pairwise Comparisons with Adjusted P Values, Phi Coefficient, and X^2 (Success)

Pairwise Comparisons	Adjusted p Value	Phi Coefficient	X^2
Minority vs Nontraditional	p = 0	φ = .10	$X^2 = 182.36$
Nontraditional vs Low Income	p = 0	φ = .07	$X^2 = 104.50$
Minority vs Low Income	p = 0	φ = -.03	$X^2 = 18.76$

Note: The adjusted p value = .0166666667 for statistically significant results.

Based on the adjusted p values, each pairwise comparison presented statistically significant differences in the proportions for the traditional and redesigned curriculums. The pairwise comparison between minority (Black and Hispanic) students showed greater differences in the proportions of success for the traditional curriculum (X^2 (1) = 182.36, p < .00001 and φ = .10).

Persistence of underprepared students based upon completion for the traditional or redesigned developmental mathematics program is shown in Table 17.

Table 17

Persistence of Underprepared Students in the Mathematics Program

Subgroup	Number of Students in Developmental Mathematics in 2009-2010 (%)	Number of Students in Developmental Mathematics/College Math in 2010-2011 (%)	Number of Students in Developmental Mathematics in 2015-2016 (%)	Number of Students in Developmental Mathematics /College Math in 2016-2017 (%)
Black	29,565 (35.60%)	12,598 (33.45%)	14,093 (35.86%)	4,817 (31.93%)
Hispanic	3,258 (3.92%)	1,617 (4.29%)	3,951 (10.05%)	1,738 (11.52%)
Nontraditional	41,252 (49.68%)	18,158 (48.22%)	16,613 (42.27%)	6,158 (40.81%)
Low Income	52,708 (63.47%)	23,996 (63.72%)	25,072 (63.80%)	8,674 (57.49%)
Total Students Enrolled	83,040	37,660	39,299	15,088

Among minority (Black and Hispanic) students, there was a 5.71% increase in the persistence rates of students who completed the redesigned curriculum. For both the nontraditional and low-income students, persistence rates declined by 7.41% and 6.23% respectively. Additional analysis for the performance of underprepared students was conducted for the persistence of the subgroups based on the developmental mathematics program of the two cohorts (traditional vs redesign). The chi-square test of homogeneity was conducted to determine if there was a statistically significant difference between the proportions of persistence in the mathematics program for underprepared students based on completion of the developmental mathematics program. These students completed developmental mathematics in the previous, 2009-2010 (traditional) and 2015-2016 (redesign), academic years. The analysis of these two proportions revealed a statistically significant ($\alpha = .05$) difference. The results for the chi-square test of homogeneity for each subgroup and persistence in the mathematics program are presented in Table 18.

Table 18

Underprepared Students' Persistence and Developmental Mathematics Curriculum

	Subgroups				
Curriculum	Black	Hispanic	Nontraditional	Low Income	Total
Traditional (Pre-Redesign)	12,598 (72.34%)	1,617 (56.75%)	18,158 (74.68%)	23,996 (73.45%)	56,369
Redesign	4,817 (27.66%)	1,738 (51.80%)	6,158 (25.32%)	8,674 (26.55%)	21,387
Total	17,415	3,355	24,316	32,670	77,756

Note: α = .05 for statistically significant results.

The two probabilities for persistence in the mathematics program were not equal in the population (X^2 (3) = 1066.49, p = 0 and Cramer's V = .1171). Completion of the Cramer's V for effect size revealed a small association between the variables. Post hoc testing was performed to determine which variables contributed to the statistically significant difference in proportions. A graphical representation for the percentages for persistence (of the total for persistence) for each subgroup, based on the completed developmental mathematics curriculum, is presented in Figure 14.

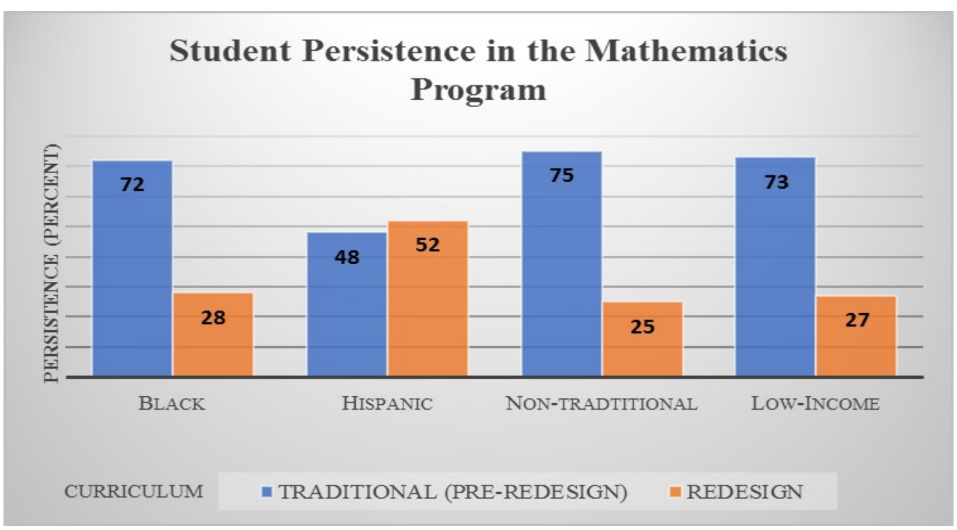

Figure 14. Persistence of Subgroups Based on Developmental Mathematics Curriculum.

With the result of statistically significant differences in the proportions for persistence of the subgroups, a post hoc test was conducted to determine which pair of variables presented the greatest differences between the proportions. The chi-square goodness of fit tests were completed on three pairwise comparisons to obtain the p value for each pair. Table 19 presents the adjusted p values using Bonferroni corrections.

Table 19

Pairwise Comparisons with Adjusted P Values, Phi Coefficient, and X^2(Persistence)

Pairwise Comparisons	Adjusted p value	Phi Coefficient	X^2
Minority vs Nontraditional	p = 0	φ = .07	$X^2 = 215.09$
Nontraditional vs Low Income	p = 0	φ = .05	$X^2 = 156.39$
Minority vs Low Income	p = .001	φ = .01	$X^2 = 10.87$

Note: The adjusted p value = .0166666667 for statistically significant results.

Examination of the adjusted p values for each pairwise comparison presented statistically significant differences in the proportions for the persistence of underprepared students in traditional and redesigned curriculums. The pairwise comparison between minority (Black and Hispanic) students showed greater differences in the proportions of persistence for the traditional curriculum (X^2 (1) = 215.09, $p < .00001$ and $\varphi = .07$).

Summary

The chi-square test of independence and the chi-square test of homogeneity were used to analyze the association and differences between categorical variables. Success and persistence of underprepared students were focal points of this study. The results of the analyses completed in this study found there to be statistically significant associations between several of the variables. The Phi coefficient and Cramer's V statistics were used to measure the strength of the association through effect size. In addition, the odds ratio was calculated to determine the likelihood of the success and persistence of the subgroups of underprepared students.

The findings of this study revealed a statistically significant association between minority (Black and Hispanic) students and success in college-level mathematics courses as well as between minority (Black and Hispanic) students and persistence in the mathematics program. There was a statistically significant association between nontraditional (over the age of 24) students and success and also between nontraditional students and persistence. There was not a statistically significant association between low-income students and success; however, there was a statistically significant association between low-income students and persistence. The chi-square test of homogeneity revealed there was a statistically significant difference between the proportions of success in college-level mathematics courses and persistence in the mathematics program for students who completed the traditional or redesigned developmental mathematics programs. These findings and interpretations are presented in the next chapter, in addition to implications and recommendations for further research.

Chapter 5: Conclusions

Introduction

Since its development in the 1960s, the role of developmental education has been to prepare the underprepared students for college-level coursework (Center for Community College Student Engagement, 2016). Research has shown an increase in the number of high school graduates and nontraditional students who are underprepared for college-level coursework and need developmental education courses (Long & Boatman, 2013). Underprepared students have been historically defined as students from low socioeconomic backgrounds, first generation college students, adult students returning to school, and minorities (Jones & Becker, 2002). More underprepared students are required to take developmental mathematics courses than other subjects (Wilmer, 2008). Research has shown that underprepared students are generally not as successful and have lower persistence rates (Boylan et al., 2017).

The purpose of this study was to determine the correlation between the demographical characteristics of underprepared (minority [defined as Black and Hispanic], nontraditional, and low income) student success in college-level mathematics courses and persistence. This study also focused on the success and persistence of underprepared students based on completion of either the traditional or redesigned developmental mathematics program. This chapter presents the findings of the data analysis, interpretation, implications of the findings relative to each research question, limitations, and recommendations for community college practices and future research.

Research Questions

The research questions and a discussion of the findings are presented in this

chapter.

Research Question 1. What is the correlation between the characteristics of underprepared students in developmental mathematics and success in subsequent college-level mathematics courses?

Research Question 2. What is the correlation between the characteristics of underprepared students in developmental mathematics and persistence in the mathematics program?

Research Question 3. How does the performance of underprepared students in subsequent college-level mathematics courses and persistence compare for students completing the traditional or redesigned developmental mathematics course sequences?

Summary of Findings

The following section contains a summary of the results for each of the three research questions guiding this study. The data analysis in this research study sought to determine the correlation between the demographical characteristics (minority [defined as Black and Hispanic], nontraditional, and low-income) of underprepared students and success in gateway mathematics courses and persistence in the mathematics program. Additionally, success and persistence of these students was examined based on completion of either the traditional or redesigned developmental mathematics curriculum.

Success in Subsequent College-Level Mathematics Courses

The first research question in the research study sought to determine the correlation between three subgroups of underprepared students and success in subsequent college-level or gateway mathematics courses. The chi-square test of independence was conducted for each subgroup to answer this question. For the first research question, the

result was a statistically significant association between minority (Black and Hispanic) students and success. Even though the chi-square test found a statistically significant association between the variables, examining the result for effect size presented a very weak association between Black and Hispanic students and success in college-level mathematics. Further analysis revealed that minority (Black and Hispanic) students were 1.31 times more likely to not be successful in a subsequent college-level mathematics course.

Analysis for the second subgroup of participants resulted in a statistically significant association between nontraditional students and success in subsequent college-level mathematics courses. Also, this association is presented as a very weak association. Calculation of the odds ratio concluded that nontraditional students were 1.32 times more likely to be successful in subsequent college-level mathematics courses.

The chi-square test of independence was also conducted for the third subgroup of participants and revealed there was not a statistically significant association between low-income students and success in college-level mathematics courses. There was no association between low-income students and success in college-level mathematics courses. Further analysis revealed that the odds for success in low-income students was approximately equal to the success of students who were not considered low income.

Persistence in the Mathematics Program

The second research question in this study sought to determine the correlation between underprepared students and persistence in the mathematics program. The chi-square test of independence was also conducted on each subgroup and found that there was a statistically significant association between minority (Black and Hispanic) students

and persistence in the mathematics program. The measure of the effect size presented a very weak or very little association. Additional analysis showed that minority (Black and Hispanic) students were 1.18 times less likely to persist in the mathematics program.

For the subgroup of nontraditional students and persistence in the mathematics program, the findings revealed a statistically significant association. The effect size returned a very weak association. The results also showed that nontraditional students are 1.10 times less likely to persist in the mathematics program.

Third, there was a statistically significant association for low-income students and persistence in the mathematics program. The Phi coefficient yielded a weak or little association; however, the odds showed that low-income students are 1.55 times less likely to persist in the mathematics program.

Traditional vs. Redesign Curriculum

The third research question sought to compare the performance (success and persistence) of students in college-level mathematics based on the traditional or redesigned curriculum. The chi-square test of homogeneity was completed and found there was a statistically significant difference in the two proportions for success in college-level mathematics courses. Further analysis to measure effect size yielded a small association. Using pairwise comparisons, there was a statistically significant difference between the proportions of each group; however, minority (Black and Hispanic) students showed the greater differences in student success.

In addition, there was a statistically significant difference in the two proportions for persistence in the mathematics program. To further analyze the data, the effect size yielded a small association. Pairwise comparisons showed there was a statistically

significant difference between the proportions of each group, and minority (Black and Hispanic) students showed the greater differences in persistence.

Discussion of Findings

Success in subsequent college-level mathematics courses. Based on the findings of this study, there was a statistically significant association between minority (Black and Hispanic) students, nontraditional students, and success in subsequent college-level mathematics courses. The participants were enrolled in developmental mathematics the previous academic year. Of the participants in this study, minority students experienced 6.64% less successes than nonminority students. Results of the study also revealed that this subgroup of students are 1.31 times less likely to be successful in college-level mathematics. Research has shown that minority (Black and Hispanic) students are overrepresented in developmental mathematics programs (Bahr, 2010; Nora & Crisp, 2012). Bahr (2010) noted that Black and Hispanic students have historically experienced lower levels of mathematical achievement beginning in the early years of mathematics education. The trend of low mathematical achievement has continued, as many of the minority (Black and Hispanic) students do not complete the developmental mathematics course sequences and therefore fail to enroll in college-level mathematics (Bahr, 2008; Brown & Spies, 2015). This study supports the research as minority (Black and Hispanic) students failed 6.38% more of the college-level mathematics courses than nonminority students.

Nontraditional (over the age of 24) students enter higher education for a variety of different reasons (Hittlepole, n.d.). This study found a statistically significant association between nontraditional students and success in college-level mathematics courses.

Knowles (1974) described adult learners as students who are motivated to learn and are self-directed. Such research suggests that nontraditional students as adult learners are motivated to ensure that learning happens. Wolfe (2012) found that nontraditional students were more likely to be successful in the first college-level mathematics course. This study is consistent with research as nontraditional (over the age of 24) students were 6.84% more successful in college-level mathematics than traditional students. In addition, this research study found that these students were 1.32 times more likely to pass a gateway or college-level mathematics course. Though Hittlepole (n.d.) declared that more of these students are required to take developmental courses, this study found many of these students are successful in remediation. Additionally, this study supports higher success rates among nontraditional students, as the findings revealed a lower percentage of failures in college-level mathematics courses for nontraditional students compared to traditional students.

Surprisingly, this research study found that there was not a statistically significant association between low-income students and success in college-level mathematics courses. Research indicates that low-income students are more likely to never obtain a degree (Burns, 2010). Obtaining a degree from a community college requires students to complete at least one college-level mathematics course. Additional research suggests that low-income students are more likely to need remediation or developmental classes and fail to complete the course sequences (Boylan et al., 2017). As such, the findings of this study are not consistent with the research. The results for this research study found that the likelihood of low-income students being successful in a college-level mathematics course was equal to the likelihood of failing a college-level mathematics course. Second,

these findings could be explained as the success rates in college-level mathematics courses were about the same for low-income students and students who were not considered to be low income.

In the review of the literature for this study, Bahr (2010) suggested increasing success in remediation could increase success in college-level mathematics. Previously, Bahr (2008) defined successful remediation as passing (a grade of C or better) a college-level mathematics course. Furthermore, some research concludes that developmental education provides access for students with different backgrounds to be successful in college (Tierney & Garcia, 2008).

Overall, the results of this research study have some implications for the future of developmental mathematics programs in SCCS. Research shows that more underprepared students (minority, nontraditional, and low-income) continue to enroll in community colleges; however, many do not complete the course sequences (Attewell et al., 2006). As such, there is a growing need to ensure that underprepared students are prepared to be successful in college-level mathematics courses by first ensuring these students complete the course sequences. This study has found that there is an association between underprepared students (minority and nontraditional) and success in subsequent college-level mathematics courses. This study did not find an association between low-income students and success in subsequent college-level mathematics courses. It is noted that the purpose of developmental mathematics courses is to provide the academic skill set necessary for previously underprepared students to perform at the same level as academically prepared students. Based on the purpose for developmental mathematics courses, the findings of this study imply that developers of the curriculum for the

developmental mathematics programs should focus on mastery, contextualization, and method of delivery to increase the success of underprepared students. In addition, developmental mathematics programs should focus on enhancing those characteristics of adult learners necessary for success, such as motivation, self-direction, and a readiness to learn.

Kalamkarian et al. (2015) proposed that incorporating mastery in the developmental mathematics curriculum ensures that students are prepared for college-level mathematics courses. In addition, Perin (2011) noted that using contextualization in developmental courses could improve educational outcomes for academically underprepared students and enhance student learning of concepts as preparation for college-level coursework. Contextualization incorporates the need to know and the orientation to learning principles of adult learners that allow adult learners to draw on life experiences to learn new concepts (Knowles, 1974). Many of the developmental mathematics courses in SCCS differ in the delivery method for mathematical content. These findings imply there is a need to research best practices for underprepared students to receive the necessary supports to successfully remediate or, in other words, be successful in subsequent college-level mathematics courses.

Some supports for underprepared students include accounting for possible external factors that may affect underprepared students such as mathematics self-efficacy and motivation. Given the reciprocal relationship between mathematics self-efficacy and mathematics performance, an increase in underprepared students' opportunities for success could increase these students' mathematics self-efficacy (OECD, 2015). Additionally, research suggests collaborative and engaging lessons allow underprepared

students to be intrinsically motivated (Ginsberg & Wlodkowski, 2009).

Examining the results of this research study leads to implications for these subgroups of students. With the association between minority (here, Black and Hispanic) students and success in college-level mathematics courses, one must understand the history. These two groups of students have been traditionally underserved for most of their academic careers, as many of these students were not in college preparatory programs in high school, do not have college knowledge, and face financial hardships. Additionally, for many of these students, there was no pathway for attendance to an institution of higher education. Black students have many life obstacles to overcome to get to the point of believing that higher education is attainable. Additionally, for Hispanic students, there are other barriers, such as language, work obligations, and mobility, to overcome for the attainment of higher education.

Through examination of the demographical characteristic of nontraditional students, this study found these students tend to be more successful in college-level mathematics than their traditional counterparts. Nontraditional students are truly capable of applying the characteristics of adult learners to drive them to be successful, though many have been out of school for long periods of time. For many of these students, attending college is not just a pastime event, it is a stepping stone to a better quality of life, which becomes a motivation for success.

This study, surprisingly, did not find any association between income and success in college-level mathematics courses, as the participants in this study were students in the developmental mathematics program. For these students, income of the students had no bearing or was not a determining factor for success or the lack of success. Research has

increasingly shown that low-income students, or students of low socioeconomic status, do not perform as well in school as students from high-income families (Mulvey, 2009). Examining the success rate of low-income students, in light of this study, one may conclude that income has no impact on the development of self-efficacy or the characteristics of adult learners to be successful in college-level mathematics. In other words, successful low-income students are driven by other factors, and income does not present a barrier.

Persistence in the mathematics program. The findings of this research study revealed a statistically significant association between minority (Black and Hispanic) students, nontraditional (over the age of 24) students, and low-income students and persistence. The findings for persistence in the mathematics program among minority (Black and Hispanic) students is consistent with the research. Research has shown that minority (Black and Hispanic) students had a low completion rate, as many of these students fail to complete the developmental mathematics course sequences. Comings (2007) defined persistence as remaining in an educational program until completion. Persistence in this study is defined as enrollment in either developmental mathematics or college-level mathematics within 1 year of completing a developmental mathematics course. A review of the literature suggests that the characteristic of being a minority (Black and Hispanic) student influenced persistence (Tinto, 1975). This research study supports the association between minority (Black and Hispanic) students and persistence with findings that more than 63% of minority students did not persist in the mathematics program from 1 academic year to the next. Furthermore, it shows that minority students were 1.18 times less likely to persist in the mathematics program. Critics contend that

enrollment of minority (Black and Hispanic) students in a developmental program has a negative impact on persistence (Goudas & Boylan, 2013); however, in contrast to this study, other research suggests that developmental education students are more likely to persist than students who do not enroll in developmental education courses (Bettinger & Long, 2005). Such findings could be attributable to the inclusion of the principles of adult learners within developmental education programs, as these programs practice a holistic approach for supporting student success (Boylan, 1999).

Furthermore, this study found a statistically significant association between nontraditional students and persistence in the mathematics program. Increasing numbers of nontraditional students are faced with many obstacles when attending community college (Crosta, 2013). Many of these obstacles become barriers to the persistence of nontraditional students (CLASP, 2015; Hittlepole, n.d.). This study is consistent with the research, as the findings indicate that nontraditional students have a slightly higher rate of not persisting in the mathematics program. In addition, this study found that nontraditional students were 1.10 times less likely to persist than traditional students. Other research indicates that these students also do not persist, as many nontraditional students work full-time jobs and support families (Boylan et al., 2017). Additional research indicates nontraditional students have an increased need for developmental education, which becomes a barrier to persistence (Hittlepole, n.d.). Hittlepole (n.d.) also suggested that creating an institutional atmosphere of support for these students could increase the rates for persistence.

Low-income students are also faced with barriers for persisting in the mathematics program (Mulvey, 2009). The financial and academic challenges of low-

income students often lead to these students failing to persist in the mathematics program or dropping out of school entirely (Kreysa, 2006). This study is consistent with research; finding a statistically significant association between low-income students and persistence in the mathematics program. Similar to minority (Black and Hispanic) students, these students also tend not to persist in the mathematics program. Findings from this study support the conclusion of lower persistence rates among low-income students, as more than 65% of low-income students failed to persist in the mathematics program. Additionally, this study found that low-income students were 1.55 times less likely to persist in the mathematics program compared to students who were not considered low income. Further, many low-income students failed to complete the developmental mathematics course sequences, thereby never enrolling in a college-level mathematics course (Brown & Spies, 2015).

Furthermore, the findings of this study resulted in additional implications for the developmental mathematics programs. As there is a need to increase the success of underprepared students, there is also a need to increase the persistence of these students in the mathematics program. Research shows that underprepared students (minority, nontraditional, and low income) generally do not persist to reach their educational goals (Burns, 2010). The findings of this study showed an association between the demographical characteristics of underprepared students (minority, nontraditional, and low income) and persistence in the mathematics program. Such results imply the need to incorporate supports in the developmental mathematics program to increase the persistence of these students. Increasing persistence for underprepared students could lead to an increase in overall college completion rates of the community college. An

increase in community college completion rates is important, as much of the funding for community colleges is based on student performance.

The review of the literature in this study has shown that increasing the self-efficacy of these students is important, as higher self-efficacy increases student persistence to completion (DeWitz et al., 2009; Tinto, 2017). In addition, research shows that students fail to persist due to a lack of a sense of belonging. As the findings of this study show that underprepared students (minority, nontraditional, and low income) do not persist at the same rates as other students, it is important to add support and an engagement system to the developmental mathematics programs. Integration and engagement activities could enhance the sense of belonging for underprepared students, thereby increasing persistence (Tinto, 2017). Last, the results of this study imply that academic supports and interventions in developmental mathematics are necessary to increase the likelihood for underprepared students to persist in the mathematics program.

Unfortunately, the cycle of underpreparedness for these students does not stop upon graduation from high school. The majority of minority (Black and Hispanic) students will be required to take developmental education courses and, for the most part, fail to complete these course sequences, thereby never reaching college-level mathematics courses. For those Black and Hispanic students who do persist to college-level mathematics courses, one has to believe that these students were able to harness those characteristics of adult learners to be self-directed and motivated for success and persistence. These characteristics are also borne out of a high self-efficacy; these students believed in their ability to successfully complete developmental mathematics and persisted to college-level mathematics courses. Developing self-efficacy in students

has to be an inherent part of developmental mathematics programs, to move more of these students forward to successfully remediate and persist to complete college-level mathematics.

For nontraditional students, many of these students have outside obligations and families to support and attend college part-time. Nontraditional students seem to have a high self-efficacy and are motivated to persist. Motivation for these students may come in many different forms, such as a new job, training to maintain a position, or personal development to change careers; however, nontraditional students apply these qualities for successful remediation and the completion of college-level mathematics courses or persistence in the mathematics program.

Low-income students are not as likely to persist in the mathematics program and need assistance to develop the motivation to continue through the supports (self-efficacy of adult learners) incorporated in developmental mathematics programs. Development of high self-efficacy can assist these students with persisting in the mathematics program to reach their educational goals.

Traditional vs. redesigned curriculum. This study found a statistically significant difference between the proportion of success between the traditional and redesigned curriculum for all the subgroups of students. In 2011, SCCS developed a plan to redesign developmental education, specifically developmental mathematics. The purpose of the redesign was to increase student success and completion of the developmental mathematics course sequences, as previous findings showed that only 8% of students were progressing through the sequences to enroll in college-level mathematics courses (Brown & Spies, 2015). Data collected were based on the last completed year of

the traditional curriculum (2010-2011). As the state system is still in the midst of the redesigned curriculum, data on the overall success of the redesign has not yet been made available, so this study focused on the fifth full year (2016-2017); however, the findings of this study are not consistent with the research regarding the traditional curriculum and the redesign. This study found that the nontraditional and low-income students performed better in the traditional curriculum, 16.63% and 14.01% respectively; however, minority students (Black and Hispanic) performed better, as a group, in the redesigned curriculum by 1.6%.

In addition to examining the success of the subgroups, this research study also analyzed the persistence of underprepared students. The results revealed a statistically significant difference in the proportions for persistence in the mathematics program for underprepared students in the traditional curriculum versus the redesigned curriculum. Nontraditional and low-income students had higher persistence rates in the traditional curriculum of 7.41% and 6.23% respectively. Minority (Black and Hispanic) students had higher persistence rates in the redesigned curriculum by 5.71%.

Currently, SCCS is preparing for a complete reform of developmental education programs. The findings in this study hold many implications for the reformed developmental mathematics curriculum. A review of these findings implies that it is necessary to develop curriculum that is focused on considering the underprepared student population in developmental mathematics courses. Research shows that most reforms and redesigns of developmental education focus on improving student success in subsequent college-level courses; however, these innovations fail to account for the characteristics of the underprepared student (Boylan et al., 2017). However, the

redesigned curriculum was developed to reduce enrollment and the amount of time underprepared students spent in the developmental mathematics course sequences (Bickerstaff, Fay, & Trimble, 2016). As such, the redesign did not consider the demographical characteristics of underprepared students in relation to success or persistence in the developmental mathematics programs. The results of this study imply that the developmental mathematics curriculum should be designed to increase the success and persistence of underprepared students accounting for these demographical characteristics.

Also, the findings of this study suggest that some aspects of the traditional curriculum could be implemented in the reformed curriculum to increase student success and persistence among the subgroups. Now, SCCS has to determine the true purpose for the reform, as the findings revealed that underprepared students were more successful in college-level mathematics courses and had higher rates of persistence in the mathematics program after completing the traditional curriculum.

Suggestions for Future Community College Practice

SCCS is reforming developmental mathematics since the redesign of 2011. With these changes, it is imperative that curriculum developers identify the academic and personal development supports in the previous curriculums to add to the new reformed curriculum. As the students of developmental mathematics continue to change, incorporating more of the principles of adult learners and adding these supports could assist minority (Black and Hispanic) students, low-income students, and nontraditional students by increasing motivation and mathematics self-efficacy.

Second, another suggestion is to provide these supports and activities after normal

business hours for evening students to increase engagement with the campus and foster a sense of belonging. Integration with the college campus and developing a sense of belonging can increase persistence for minority (Black and Hispanic), low-income, and nontraditional students.

A third suggestion is to identify best practices, such as mastery and contextualization, from both the traditional and redesigned curriculum to incorporate into the new reformed curriculum. Based on the findings from this study, Black, low-income, and nontraditional students performed better and had greater persistence in the traditional (16-week) curriculum versus the redesigned (4-week) modules. Hispanic students performed better and had greater persistence rates in the redesigned curriculum. A combination of the best practices and supports from each of these curricula could increase success in college-level mathematics courses and persistence in the mathematics program for underprepared students.

Limitations

There were limitations for this study. The first limitation was that there were possible differences in the developmental mathematics curriculum for each community college. During the redesign of the developmental mathematics program, each of the community colleges were only given the direction to divide the curriculum into eight modules. In addition, the implementation rate of the fully redesigned program was not consistent across the state. As for the traditional curriculum, there were no statewide guidelines for the developmental mathematics courses. The second limitation was the implementation of Multiple Measures. Multiple Measures is an additional method to determine college readiness using high school GPA (within the last 5 years) and scores

on the ACT and SAT. Full implementation of multiple measures occurred in the fall semester of 2016. With the implementation, the demographics of the student body changed, as many traditional students were able to bypass developmental mathematics based on these measures.

Recommendations for Future Research

Overall, this study found there were statistically significant relationships between the demographical characteristics of underprepared students and success and persistence. Several recommendations for future research were developed to further the research on this topic.

As the achievement gap for minority, nontraditional, and low-income students continues to exist, the first recommendation is to determine the interventions and supports necessary for increasing the success of these subgroups. With the holistic approach of developmental education programs, students may receive additional or supplemental instruction that may impact success in college-level mathematics courses. Adding a variable or qualitative analysis for these supports may strengthen this study.

A second recommendation is to add the subgroup of first-generation students, as there is a growing population of these students in the community college. First-generation students were not added to this study, as the system was unable to capture this data. Future research examining the success and persistence of these students could prove vital to the development of curriculum and supports offered in the developmental mathematics program.

Third, as SCCS is reforming the developmental mathematics program, it is recommended to examine the data for these subgroups of students over the years of the

redesigned curriculum. Information gathered on the impact of the redesigned curriculum on student success in a college-level mathematics course and persistence in the mathematics program could provide valuable insight for the new reformed curriculum.

Conclusion

This study focused on the demographical characteristics of underprepared students and success in subsequent college-level mathematics courses as well as persistence in the mathematics program. Additionally, this study compared the performance of underprepared students and success and persistence based on the completion of the traditional or redesigned developmental mathematics program. A review of the findings implies that the traditional developmental mathematics program led to greater success rates overall for underprepared students in college-level mathematics courses, with the exception of the Hispanic students. These students tended to perform better in the redesigned curriculum. Greater success and persistence rates, based on the developmental mathematics program, could be attributed to the shorter time frames for the modules, allowing the students to progress quickly through the course sequence. Additional implications are that the demographical characteristics of minority (Black and Hispanic), nontraditional (over the age of 24), and low-income students can be a deterrent for success in college-level mathematics courses and persistence in the mathematics program, without proper interventions and access to academic supports. Supports and interventions in the developmental mathematics program should be incorporated to enhance the characteristics of adult learners for motivation and to increase self-efficacy for success and persistence.

Research has been divided as to the impact of the developmental mathematics

program on the success and persistence of these subgroups, specifically as it relates to mathematics courses; therefore, the findings in this study add to understanding the connections between underprepared students and success in the college-level mathematics courses and persistence in the mathematics program.

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Appendix A

Email to Request Information About the Data

Reply all | Delete Junk | ...

Data for Research

PE Pamela Edwards
Mon 8/6/2018 4:23 PM
To: rpm@nccommunitycolleges.edu

Sent Items

Hello,
My name is Pamela Edwards. I am completing a research study on students in Developmental Mathematics. I have approval for the Proposal and would like information for completing the IRB process. The data I will be requesting consists of student grades in gateway Mathematics courses for students who completed Developmental Mathematics courses in 2010-2011 and 2016-2017. In addition, enrollment data for DMA and gateway Mathematics. Can this data be disaggregated into subgroups of minority (Black and Hispanic), students over 24 years of age, first-generation, and low-income (qualify for Pell Grant)? Please respond with the next steps to complete the paperwork for IRB and receive the data.

Thank you,
Pamela Edwards

Appendix B

Email Request for Interest in the Study

From: Edwards, Pamela <PEdwards@email.pittcc.edu>
Sent: Monday, March 19, 2018 3:54 PM
To:
Subject: Dissertation Study for Developmental Mathematics

Hello,

My name is Pamela Edwards. I am currently a student at Gardner-Webb University, working to obtain my EdD in Curriculum and Instruction. As a part of the program requirements, I have to complete a Dissertation Study. The topic for this study is Developmental Mathematics. I am submitting this letter and a sample of the Dissertation topic and research questions to request permission to conduct the study at your institution. All data and names of the colleges will be changed for anonymity. I look forward to hearing from you soon.

Thank you,

Pamela D. Edwards, MS

Appendix C

Letter of Interest for Research Study

Bridging the Gap: How Successful is Developmental Mathematics in Preparing Students for College Level Coursework?

According to Attewell, Lavin, Domina, and Levey (2006), 58% of students are placed into developmental education. In addition, only 30% of the students enrolled in developmental mathematics courses successfully pass their courses (Attewell, Lavin, Domina, & Levey, 2006). As more students enroll in developmental mathematics, the rate of students completing college is quickly declining as students that place into developmental mathematics courses do not achieve their educational goals (Bonham & Boylan, 2011). “Developmental mathematics programs, including course and related support services, ostensibly exist on college campuses to help students achieve their goals” (Bonham & Boylan, 2011). “If remedial courses are to remain an important part of developmental education, researchers need to determine if they truly prepare students for future college work and how the courses fit into the full range of services for developmental students” (Brothen & Wambach, 2012). The conceptual framework for this study is a focus on examining the impact that enrollment into developmental mathematics courses has on mathematical self-efficacy, student retention, and student success.

This study will be a pre-experimental study that will encompass the collection of quantitative data. A survey will be administered to students to measure the students’ mathematical self-efficacy, prior to entering a Developmental Mathematics course and at the end of the course. Additional data will be examining the students’ grades in relation to the courses for student success and preparation for college level course work (after completing a gateway course) and determining if there is any correlation between the

number of Developmental Mathematics courses and student retention. The research questions guiding this study are:

1. What effect does Developmental Mathematics have on students' mathematics self-efficacy?

2. How does Developmental Mathematics impact student success in college-level mathematics courses as measured by a "C" or better?

3. How does enrollment in one or more Developmental Mathematics course impact student retention over the course of the academic year?

Current research focuses on the success of developmental mathematics in preparing students for college-level mathematics course. Additional research is needed to determine the extent Developmental Mathematics has on student success. Findings from this study could be used to reform Developmental Mathematics on the community college campuses. As such, it would be an honor to be able to complete this study at your community college.

Thank you,

P. Edwards