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ARE COLLEGE STUDENT SUCCESS COURSES EFFECTIVE COREQUISITES TO DEVELOPMENTAL MATHEMATICS IN COMMUNITY COLLEGES?

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ABSTRACT

The purpose of this study was to examine the differences in the achievement rates of developmental mathematics students when a student success course was taken in combination with mathematics. The study investigated changes that occurred in the developmental mathematics completion rates of the learners by examining age and the course sequence of mathematics in conjunction with a student success course at a large community college in central Florida. Age was of interest as it related to the time lapsed from high school graduation and potential for mathematics atrophy. Course sequence was valued to determine if taking a student success course during or within one year of developmental mathematics could enhance mathematics course completion. These attributes were further divided and assessed according to the two specific developmental mathematics courses. Level 1 consisted of learners in deep remediation needing the most basic developmental mathematics course. Level 2 was composed of people who placed into the developmental mathematics course just below that of 100-level coursework.

The results of the study from multiple analyses of association revealed that developmental mathematics course completion was significantly correlated to student success courses. Students who took a student success course as a corequisite to their developmental mathematics course completed their mathematics course more often than those who took mathematics alone. Additionally, students in the higher level developmental mathematics course also performed significantly better when a student success course was taken before but within one year of their developmental mathematics course.

In the age groups of participants in the study, students who had been out of high school longer did not experience any observable mathematics atrophy when taking mathematics without a student life skills course. As compared to younger students (20 years of age or younger), older students had a significantly higher course completion rate. Moreover, all age groups in the study were shown to have benefitted significantly from the inclusion of a student success course. Younger learners in the lowest level developmental mathematics course, however, benefitted most. This study provides implications for practices and policies that enhance developmental mathematics course completion and facilitate academic momentum to degree completion in community colleges. It also provides insights to enhance developmental mathematics curriculum success from an approach peripheral to the discipline.

PREFACE

Community colleges are unique and important in providing access to higher education. Community colleges benefit those who wish to stay in their community to be close to family or work. They provide an alternative for those who are turned away from colleges and universities due to academic deficiencies. And for other first-generation college students like me, community colleges provide a cost-effective way to explore the possibilities, learn the ropes, and determine life's path. Regardless of the reason for attending, community colleges embody an academic rigor that can be challenging to navigate. Many students enter the open-access institutions unprepared and require developmental coursework and college skill preparation to provide the foundation required for advanced learning success.

Mathematics is the greatest area of deficiency community colleges encounter. This study was prompted by my experiences in teaching developmental mathematics and serving as dean over both developmental education and college success courses. This employment instilled in me the belief that the high enrollment and low success rates of developmental mathematics are not a result of poor teaching, deficits in the curriculum, or inattentive students. Instead, my experience led me to conclude that developmental students need to learn how to navigate college and develop solid practices of learning. Therefore, this study and its findings are a salute and an apology to those who have struggled, endured multiple transformations and formats of developmental mathematics course delivery, and felt less than what they were capable of accomplishing because they were never taught skills for college academic success.

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Finally, I express deep gratitude to my husband, Mark Reilly. I have been continuously enrolled in coursework and accomplishing educational goals since the day we met. I am looking forward to starting a new chapter with him. Selflessly, year after year, he gave of his time and resources ensuring I had a comfortable place to study, ideal technology, and when needed, a study partner. He has always put my professional dreams first and made sacrifices to see them through. We have talked through so much material together; I feel any degree I attain is also warranted by him. You are my soul mate and I love you. May God bless us with many more

years as he has blessed and guided me with unconditional love, faithfulness, and care throughout this educational journey.

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CHAPTER 1

INTRODUCTION

Developmental education (also known as remedial education) courses were introduced into higher education through community colleges in the early 1900s (Boylan & Saxon, 1998). Historically and culturally, in the community college context, developmental education's intent is to increase the basic skill level of adult learners to that of students who enter college program-level courses directly. Developmental coursework typically involves study in the area of reading, writing, and/or mathematics as is needed by the individual.

In 2000, 76% of higher education institutions provided some type of remediation (Jenkins & Boswell, 2002). Over time, however, the community college system has become the primary source for students in need of developmental education (Perin, 2006). The Education Commission of the States in 2002 focused their entire agenda on making community colleges solely responsible for developmental education (Jenkins & Boswell, 2002). Among others, both Nevada and Indiana no longer fund remedial education at four-year state universities; it is funded at the community college level (Plucker, Wongsarnpigoon, & Houser, 2006).

Because community colleges have an open access system, it isn't surprising that the greatest dropout rates experienced in higher education occur within community colleges (Karp, 2011). Karp (2011) found that of those who entered community colleges in the 2003-2004 academic year, 45% departed from their institutions without a credential prior to the end of their third year. He attributed this, in part, to the high concentration of students in developmental courses. Nonetheless, a growing number of students are choosing community colleges as their institutions of higher education. Almost half of all college students in the nation attend community colleges (Barefoot, 2004). Affordability, flexibility in course scheduling, guaranteed transfer to four-year schools, developmental education options, and the nearby location are a few of the elements that have caused a 22% increase in community college enrollment since 2007 (Mullin & Phillippe, 2011).

The developmental student population at community colleges is large. In 2010, half of community college students were required to enroll in remediation; 35% of those were in mathematics (National Center for Education Statistics, 2010). Of those who need basic skill review, the majority are consistently deficient in mathematics. Regrettably, it is not unusual for remedial students to spend one or two years in basic mathematics courses before advancing to their program-level course work (Bahr, 2011). Additionally, few individuals make it through a developmental mathematics course on their first attempts. If they do reach college-level mathematics courses despite the delay, frustration, and computational challenge most fail to attain mathematical proficiency at the college-level (Bahr, 2011). On average only 30% of developmental mathematic students make it successfully through their required mathematics sequences (National Center for Education Statistics, 2010).

To address the lack of success in developmental mathematics, colleges have pursued delivery alternatives and course redesign, but no single practice has emerged as an effective model that can be scaled up and/or repeated across community colleges (Bonham & Boylan, 2011). Some say this is due to a lack of research effectively documenting these practices (Rutschow & Schneider, 2011). Others contend that the differences in populations make it hard to expect the same results (McCabe & Day, 1998). Regardless, the success rate in developmental mathematics remains low and requires further study.

Statement of the Problem

Over the last decade, most students have required developmental coursework when entering community colleges (Barefoot, 2004). Many of them fail to complete their developmental coursework on the first, second, or even third attempt (Charles A. Dana Center, Complete College America, Education Commission of the States, & Jobs for the Future, 2012). It is not, therefore, surprising that Adelman (1996) found that students in need of developmental mathematics, reading, and/or writing tend to complete their degrees at much lower rates than non-developmental students. Consequently, developmental education is a barrier to degree and career goal attainment for students.

Although many have looked at ways to improve upon the content and delivery of remedial courses, Barefoot (2004) contended that the struggles new students experience are not necessarily specific to discipline pedagogies. Her findings suggested that first-year learners are unaware of the skills needed to be successful in higher education; developmental learners are experiencing the rigors of college for the first time and are unprepared for the challenges. Navigating the nuances of the college experience, developing appropriate time management and study skills, and building a new social network that provides support have been noted as essential for college success (Tinto, 2013). These vital components, however, are seldom considered in the context of a specific discipline and may offer an explanation for the low success rates in developmental education (Karp, 2011). Postsecondary education is a new environment where students must learn how to engage, navigate, and meet expectations successfully (Rosenbaum, Deil-Amen, & Person, 2006). Pathways that address college success skills in combination with developmental education could assist students in meeting their educational aspirations. Furthermore, Bonham and Boylan (2011) have shown that remedial mathematics is the discipline required by the majority of incoming college students and has the highest rate of failure at any community college. By using the developmental mathematics population as the focus of this study, there was an opportunity to understand the impact of developmental education from the vantage of the largest subset of the population.

Many attempts have been made to improve developmental mathematics' student success through alternate forms of curriculum delivery, but only modest gains have been noted (Bonham & Boylan, 2011). Research exists in this area; however, there are other opportunities to enhance developmental mathematics learning unrelated to the computational curriculum. Wade (1994) stated that entering college students lack experience, frequently lack maturity and, consequently, confidence. Rocca (2010) contended that students who lack confidence in their ability to succeed in college fail to engage in their coursework. Rocca's findings were similar to student surveys that also noted confidence as the single most important quality students need to possess in order to actively engage in a course (Weaver & Qi, 2005). This is relevant because Gasiewski, Eagan, Garcia, Hurtado, and Chang (2011) found that students who are engaged and take initiative do better academically in science, technology, engineering, and mathematics. Engagement can be defined in many ways. Handelsman, Briggs, Sullivan, and Towler (2005) demonstrated that engagement in the form of participation increased grades. None of the aforementioned studies focused on changing computational pedagogies. Instead, they seem to indicate that student success can be enhanced by addressing skills unrelated to the discipline, much like those found in college success courses.

Traditionally, students' navigation and engagement in college has been treated separately from their academic performance. This is indicative of the silos created by the divisions of student affairs and academic affairs in some institutions. The office of student affairs typically provides orientation, counseling, and advising as well as a selection of clubs and activities that allow students to navigate and engage socially. Academic affairs provides curriculum within disciplines, programs, and majors that focus on learner acquisition of specific knowledge. However, there is evidence to indicate that developing college know-how, clarifying aspirations, building social relations, and providing tools for challenges can ease students' paths toward a degree (Karp, 2011). Courses do exist that espouse these outcomes and are traditionally known as college student success courses. At many colleges, student success courses are offered and, occasionally, required. Due to the nature of the content of student success courses, it is often student affairs professionals who provide instruction in the curriculum. If the courses do reside within academic affairs, typically they are treated as peripheral entities that have no direct connection to other disciplines (Karp, 2011).

Adelman (2006) suggested that an undergraduate's early course load and subsequent success are instrumental in degree completion. He defined this as *academic momentum*. Students who progress through their coursework at a given pace are more likely to achieve their educational goals than students who progress slowly through their paths. Attewell, Heil, and Reisel (2012) further substantiated this claim in noting that students who take and pass a full load of college credits early on tend to take and be successful in the same manner in subsequent terms. Consequently, academic momentum holds value for the developmental student. If it were possible to find a pathway that allowed developmental mathematics students to complete their courses successfully on the first attempt, the momentum achieved would theoretically enhance degree completion as well. In facilitating academic momentum, it becomes quite relevant to ask if college student success courses could be effective corequisites in allowing more students to overcome the developmental mathematics hurdle so many require in higher education.

Purpose of the Study

In consideration of the large number of students who must take developmental mathematics, and the subsequent low pass rates, it is prudent to ascertain if a college success course could enhance students' ability to pass developmental mathematics upon the first attempt (Bonham & Boylan, 2011). Research indicates that basic skills education with multiple support mechanisms is a more effective pedagogy when compared to similar courses that teach through traditional lecture (Boylan, Bliss, & Bonham, 1997). In many cases, instructors find it essential to embed support structures for the increasing number of students with at-risk attributes entering college (Barefoot, 2004). Additionally, several studies indicate that the objectives associated with college success courses are invaluable in enhancing student confidence and success in college (O'Gara, Karp, & Hughes, 2008; Rocca, 2010; Welkener & Bowsher, 2012). Fewer studies are available, however, that demonstrate how college success courses correlate to success in a given discipline or how strategic, corequisite scheduling of the course may enhance student learning. This study adds to the available literature from this unique perspective.

Significance of the Study

Remediation rates have increased in recent decades and are particularly high at two-year community colleges that provide open admission regardless of the level of academic preparation (Calcagna & Long, 2008). Half of all incoming college freshman at community colleges are placed into remedial level courses with the majority of these classes required in developmental mathematics (Adelman, 1996; Complete College America, 2012). Of those requiring developmental mathematics, many find themselves in deep remediation, needing two or more levels of the basic discipline (Adelman, 1996). Regrettably, when more than one level of mathematics remediation is required, statistics show that persistence and retention decline (Charles A. Dana Center et al., 2012). Consequently, fewer than 20% of those in deep mathematics remediation in community colleges are successful in completing their remedial coursework within three years (Charles A. Dana Center et al., 2012). Not surprisingly, lawmakers are questioning the need to fund academic preparation that should have already occurred in the secondary setting (Calcagna & Long, 2008). Several states, including Florida, have introduced bills that entirely eliminate developmental education at the postsecondary level due to statistics indicating low pass rates and high costs (Education Act 1720, 2013). This would be devastating for the large numbers of underprepared community college students that would lose access to the services they need. McCabe (2000) reported these entering student numbers to be over one million every year. Rosenbaum, Stephan, and Rosenbaum (2010) stated that nearly half of all incoming college students are now attending community colleges. The juncture is critical; pathways and pedagogies need to be found that enhance remedial student success. This study provides findings that suggest developmental mathematics' student success can be enhanced by taking a corequisite college success course. This evidence can be used to inform legislative initiatives considering the elimination or retention of developmental education. It also can provide insight into methodologies that positively impact future developmental mathematic populations within community colleges.

Additionally, there appears to be limited information available on the effects of corequisite learning strategies for developmental mathematics education. Mireles, Offer, Ward, and Dochen (2011) bolstered the need for this proposed study in their work. They found that there is a void in available research aimed at the specific needs of developmental mathematics learners as they relate to study strategies.

Research Questions

This study investigated the relationship between college student success courses and developmental mathematics. Remedial mathematics in conjunction with a student success course provided an enhanced opportunity for mathematics course completion upon the first attempt. In turn, time spent in remediation decreased and academic momentum was facilitated, leading to completion of students' educational goals (Adelman, 2006). More specifically, this study answered the following questions:

1. When a student success course is taken as a corequisite to developmental mathematics, do students perform better in the developmental mathematics course?
2. In looking at the two levels of developmental mathematics in a community college, does a corequisite student success course have a greater impact on one level over another?

In order to address the variable of time since high school graduation (time since exposure to mathematics content), there was a need to ascertain these questions:

3. Does the duration from high school graduation to developmental mathematics course enrollment impact student success in the course?
4. Can a corequisite college success course be used to mitigate any difference found by age in course completion?

Null Hypotheses

The null hypotheses of the study suggested that developmental mathematics students are equally successful as those who simultaneously take a college success and developmental mathematics course. That is, I assumed student success course initiatives to be unsuccessful in accomplishing the goal of enhanced developmental mathematics completion rates.

H_o1: There is no statistically significant difference between Level 1 and Level 2 developmental mathematics course completion rates regardless of whether a student success course is taken as a corequisite.

H_o2: There is no statistically significant difference between Level 1and Level 2 developmental mathematics course completion rates regardless of whether a student success course is taken within one year of taking the developmental mathematics course.

H_o3: Regardless of whether a student success course is taken as a corequisite, there is no statistically significant difference between the age groups for students' developmental mathematics course (Level 1and Level 2) completion rates.

H_o4: Regardless whether a student success course is taken within one year, there is no statistically significant difference between the age groups of students' developmental mathematics course completion rates in Level 1and Level 2.

Population and Sample

In order to determine if a college success course taken in conjunction with a developmental mathematics course increased completion rates of students in developmental mathematics, a post-facto study was imposed on the representative groups composed at random from the population. Three groups were established and examined based on the condition in which they took their developmental mathematics course. Additionally, in order to reduce the external threat to validity, the students were selected for study based on their Post Secondary Education Readiness Test (PERT) mathematics scores (Klingman, Castellano, & Kelley, 2008). The first group completed developmental mathematics independent of a college success course.

The second group completed their developmental mathematics course while enrolled in a college success course, and the third group completed developmental mathematics after taking a college success course within the past academic year.

In addition to PERT mathematics scores, the groups were comparable due to the common curriculum utilized in the developmental mathematics sections and a common curriculum in the student success sections. In each area, a single department chair assured that faculty training for the course was conducted uniformly. In turn, this facilitated instruction that was common across the department. These measures were strictly adhered to as the College has a rigorous process for assessing student learning outcomes in each discipline. This consistency allows for meaningful data that impacts curricular decisions. Consequently, it is reasonable to anticipate that each student's educational experience in developmental mathematics and each student's experience in student success was similar.

Definition of Terms

Academic momentum: Disposition acquired through successful completion of early college courses that help to propel learners to their academic goals (Adelman, 1992).

College knowledge: Self-awareness and ability of students to interact with their peers, faculty, staff, and academic community in the college environment (Conley, 2007).

College student success course: Course providing foundational competencies in time management, note taking, study skills, goal setting, and career exploration with the intent of enhancing any given student's college and academic success; also termed college success, first year experience, and freshman seminar.

Developmental education: Basic skills deemed below the level of college readiness; often called remedial or compensatory education. For purposes of this study the term is used interchangeably with *remedial* and is ascribed to the skills inherent in reading, writing, and mathematics.

Deep remediation: A disposition that is caused by the need to remediate in two or more levels of basic skill review in a single discipline or in multiple disciplines.

Mathematics anxiety: A common condition that makes it difficult for students to concentrate and perform in their computational coursework. It is common among adult learners and especially developmental students. Although it varies in intensity, mathematics anxiety is characterized by panic, helplessness, and mental paralysis (Nolting, 2002).

Limitations

Although the study suggested a correlation between developmental mathematics and student success courses, the research did have its limitations. First, the study was limited to learners taking courses at Valencia College. As such, there was an assumption that each developmental mathematics course and student success course embodied the same objectives and was facilitated with similar pedagogies. Next, there was variability in each student's proficiency. All students in the study had taken a college entrance exam to determine developmental or college-level course placement. The scores were all within a given range but there was little difference between a student that scored just into program-level study and one that entered remediation one point below the cutoff (Martorell & McFarlin, 2011).

Hughes and Scott-Clayton (2011) suggested a non-aptitude related issue why students may place into remedial studies that could have been a limitation in this investigation. Certain students may have taken the placement exam unaware of its consequences. During the admission and registration process, many community colleges move students from one point to the next in a sequential manner. First-time students simply go from one line to another often unaware of what they are to encounter. The placement test is part of this process. Once they arrive at this point, often after hours in other areas of the college, they navigate the assessment quickly so they can move on. Hughes and Scott-Clayton contended that it is likely that a portion of this population could score much higher and pass through the remedial stage of coursework if they understood the implications, prepared for the event, came in fresh, and then took their time on the assessment. This holds true for students coming directly from high school as well as for returning students who may simply be in need of a review after being out of school for many years. In both of these situations, students are predisposed to a higher degree of success in the remedial course as well as their subsequent courses (Hughes & Scott-Clayton, 2011). Their success in this study may not be attributable to the corequisite student success course.

Further, in this study, intrinsic factors in the population varied and caused different levels of student motivation. Student attitudes and values will impact the level to which a student is engaged in the classroom (Elliott & Tudge, 2012). Additionally, the macrosystems in which students live impact their performance. Bronfenbrenner's (2005) bioecological model suggested that student learning is influenced by their home environment and social connections. It is unknown if individual student success or failure in the developmental mathematics course was a result of the students' educational experience or due to variables in the environment, support mechanisms, personal issues, or other outlying factors. Because community colleges enroll the greatest number of economically and socially disadvantaged students, this element could have significantly impacted the academic outcome of some more so than others (O'Gara, Karp, & Hughes, 2009).

Delimitations

This resulting study can be generalized to a rather large portion of the population. Although a college's curriculum is specific to its remedial courses, remedial education typically involves instruction in the same basic skill objectives. Likewise, student success courses vary by institution but are based on a similar platform that includes setting academic and personal goals, effective communication, study strategies, and learning styles (Barefoot, 2000).

Research Assumptions

It is anticipated that the diverse demographics of the sample in this study were representative of the community college population at large; therefore, the results can be generalized. The cutoff scores for the placement exam assume that all within the range had an equal chance of success in developmental mathematics. Success was indicated by a grade of C (69.5%) or better in the course. In a similar manner, by only including those in the population who completed the student success course with a passing grade of 60% or higher, there was an assumption that each student could utilize the strategies in the course equally as successful.

It was assumed that the methodology of instruction in the developmental mathematics and student success courses (when applicable) were the same. A common curriculum was used. Faculty members were given basic information on how to conduct the courses. Even though the remedial students in the sample did not necessarily have the same instructors, they were considered to be equally prepared for the next mathematics course in the sequence after completion of the developmental level.

The time of day that a course was conducted, day of the week, and the classroom location were not considered to be a detriment to the study. This was based on the premise that the course content and classroom design were fairly uniform. Interruptions in the instructional schedule were also not considered, including holidays and unforeseen conditions such as instructor illness or other reasons of absence.

CHAPTER 2

LITERATURE REVIEW

Developmental Education

Remedial programs in higher education have been the subject of criticism over the last several decades (Charles A. Dana Center, et al., 2012; Gallard, Albritton, & Morgan, 2010). Opponents to remediation have argued that remediation is nothing more than a barrier to degree attainment. That is, it is a hurdle that prevents enrollment in college-level coursework (Calcagno & Long, 2008). Remediation efforts are criticized for using tax payers' dollars to re-teach material that should have been mastered in high school (Bettinger & Long, 2009). Nonetheless, developmental education remains a core offering at institutions of higher education across the country. Two-year, open access, community colleges specifically see high rates of remedial students due to their relaxed entrance requirements (Dougherty, 1994).

In this context, by definition, the goal of remediation is to get individuals to a level of skills and understanding that subsequently allows them to enter and successfully complete their college-level coursework. Adelman (1998) found that it is not uncommon for students to find themselves in need of more than one level of review in a discipline or multiple disciplines. He established that the necessity for this *deep remediation*, in turn, causes a decrease in retention and persistence among these students. It adds time, money, and often frustration to the aspiring college student's educational challenges. Adelman contended that if remediation takes longer than one year to navigate, the degree completion rate drops significantly; the longer students spend in remediation, the less likely they are to achieve their academic goals.

Although criticism is abundant in the literature, remedial education is not without its supporters. Evidence exists describing a positive correlation between enrollment in remedial coursework and retention in the first year of college (McCabe, 2000; Sinclair Community College, 1994). Additionally, research conducted by Batzer (1997) indicated that those who take and complete all levels of their remedial courses successfully tend to persist to graduation at rates above those that did not participate in remediation. The study suggests that students are more likely to take advantage of support mechanisms and seek assistance when they first begin to struggle. Thus, three unrelated studies add to the evidence that successful developmental students are successful in their college-level coursework (Batzer, 1997; McCabe, 2000; Sinclair Community College, 1994).

Logic may lead one to think that remediation in a given discipline should provide an enhanced opportunity for student success by providing a solid foundation from which to build. However, there is much more research that seems to indicate that there is a level of diminishing returns for the remedial learner. Students in need of deep remediation, such as those who need two or three levels of mathematics, were found to complete their degrees at lower rates than non-developmental students or students in need of just one level of remediation (Adelman, 1996). O'Gara et al. (2009) reasoned that for many students the time requirements involved with deep remediation impose a sense of overwhelming despair and ambiguity of attainable goals. Additionally, absence of motivation, lack of commitment, and the negative impact of circumstances often associated with urban, low socioeconomic populations in community colleges are compounding impediments to developmental student success (O'Gara et al., 2009).

Community Colleges and Developmental Education

Across the United States, half of all college freshmen require some type of remedial coursework (Barefoot, 2004). However, only 1% of higher education funds are spent on remediation in the United States (McCabe, 2000). This requires prudence in establishing effective programs that address the needs of remedial students. Throughout the last decade, community colleges have increasingly become the primary provider of developmental education (Perin, 2006). According to McCabe (2000), 95% of community colleges offer remedial coursework with up to 65% of the students enrolled in the courses. In some states developmental education funding is only provided to two-year, state institutions (Plucker et al., 2006). Young (2002) contended that remediation belongs in the community college as the need is abundant in the setting, most effectively dealt with by those accustomed to the pedagogy, and fiscally more feasible through centralization. Indeed, this notion has played out over the years. Community colleges are at the forefront of developing and implementing best practices in remediation (Cohen & Brawer, 2008).

History of Developmental Education

It is hard to determine a point from which developmental education emerged. As early as 1869, literature shows a growing concern for the ineffectiveness of schools in educating the American population (Cohen & Brawer, 2008). At the end of the 19th century, data show that there were approximately 240,000 students enrolled in higher education with 40% of these participating in pre-collegiate programs (Ignash, 1997). Further, it is difficult to ascertain if basic education has digressed over time. Although it is a common perception that basic reading, writing, and arithmetic skills have declined in our society, Cohen and Brawer (2008) pointed out that the American education system has never had a universal measure of learning. There is very little data to support this claim. In fact, some information from normed college entrance exams suggests that from the turn of the century to the 1950s there was an actual increase in academic performance (Cohen & Brawer, 2008). However, this same data does indicate a sharp decline from the 1960s to the 1970s (Cohen & Brawer, 2008).

From the 1950s to the 1970s, access to higher education grew exponentially across the nation. Converging events such as the implementation of the GI Bill, the passing of the National Defense Education Act after the launch of Sputnik, and the Higher Education Act resulted in nine million additional college freshmen enrolling (Bowen, Chingos, & McPherson, 2009). During these same decades, there was also a shift in secondary school requirements. Cowen and Brawer (2008) noted decreasing proficiency requirements in reading, writing, mathematics, and science for high school graduation and suggested that these combined events resulted in a large number of students who were not prepared for college-level work. Adelman (1992) described the influx of underprepared students as gravitating to open-access community colleges. He noted that in the 1960s, there were 654 two-year community colleges in the United States. By 1980, there were close to 1400, enrolling 44% of first-time college freshmen across the country (Adelman, 1992). Community colleges provided a higher education option to those unable to gain access to the four-year universities (Cohen & Brawer, 2008).

With the growing postsecondary population, it quickly became apparent that community colleges needed a way to sort students in order to determine those who were college ready and those who were not. College assessments, also known as placement tests, became the standard (Hughes & Scott-Clayton, 2011). In the 1970s, however, opposition to assessment testing grew based on the belief that they unfairly limited access to higher education, particularly for minorities and the socially disadvantaged (Hughes & Scott-Clayton, 2011). Hughes and Scott-

Clayton (2011) described the movement as being centered on the notion that students had a right to enter college and, as adults, they had the right to pass or fail. This philosophy of *student right to fail* quickly spread. As a result, placement tests, as well as the related concept of course prerequisites, were eliminated (Hughes & Scott-Clayton, 2011). By the end of the decade, course failure and dropout rates were at an all-time high (Young, 2002). Miami Dade Community College (MDCC) in Florida was among the first to reestablish a procedure that required all incoming students to complete a mandatory assessment test or enroll with an alternate competency on file such as an SAT score (Young, 2002). As a result of MDCC's strength in their enhanced completion and retention rates, the methodology was adopted and/or reestablished by community colleges and other universities across the country (Young, 2002).

At the secondary level, mathematics and science achievement continued to decline through the 1970s (College Board, 1994). In the early1980s, scores on the National Assessment of Educational Progress from the College Board bottomed out. Cohen and Brawer (2008) found that in just a few decades scores in science went from an average of 305 to 282 and in mathematics from 304 to 298. SAT mathematics scores indicated a drop from 494 to 466 over the same timeframe (College Board, 1994). Consequently, the need for developmental education grew as the gap from high school to college widened. The last decades have shown little change in this disposition (Cohen & Brawer, 2008).

As developmental education grew, new methodologies and best practices emerged. Nationally, however, the scalability of these pedagogies has produced mixed results (Rutschow & Schneider, 2011). Student populations, learning environments, and institutional support for developmental efforts impact developmental course outcomes as much as the programmatic framework (Bronfenbrenner, 2005). Some institutions may do developmental education slightly better than others but overall success rates across the nation have remained relatively constant (Rutschow & Schneider, 2011). Adelman (1998) noted that approximately 50% of students in remediation pass their coursework on the first attempt. Far fewer persist through the developmental sequence. Of those in deep remediation, less than 5% will attain their academic goal (Adelman, 1998).

Typically, developmental coursework does not count towards a degree and is not figured into a student's official grade point average (Calcagno & Long, 2008). Federal aid does, however, pay for a limited amount of remediation. With numerous remedial courses a single student can require, the allotment of federal assistance is often depleted. As a result, students must pay out of their pocket to complete their remediation, and/or for their subsequent program-level courses (Calcagno & Long, 2008).

Developmental Mathematics

Of those that need developmental education coursework, the majority are consistently deficient in mathematics (Adelman, 1996). Mathematics is considered to be among the hardest skills encountered in education. Nolting (2002) described it as a task learned in sequential order; if one skill is missed, each subsequent lesson becomes increasingly difficult. More specifically, the developmental course of Basic Algebra is noted as having the highest failure and withdrawal rate of any course in higher education (Bonham & Boylan, 2011). Few individuals make it through a developmental mathematics course on their first attempts (Bahr, 2011). Regrettably, it is not unusual for remedial students to spend one or two years in basic mathematics courses before advancing to their program-level course work (Bahr, 2011). If they do reach college-level mathematics courses despite the delay, frustration, and computational challenge, most fail to attain mathematical proficiency at the college level (Bahr, 2011). On average only 30% of developmental mathematics students make it successfully through their required mathematics sequence (National Center for Education Statistics, 2010).

It isn't clear why the need for remedial mathematics is high in the United States. Some researchers suggest that it is not associated with pedagogy (Nolting, 2002). Nolting (2002) is one such researcher who felt society had made it more acceptable for students to fail in mathematics. He contended that fear and hate had been perpetuated and poor performance touted as a result that was to be expected. This theory, however, is not universal in application. Despite the social construct of mathematics failure, many students do succeed even though they loathe computational problem-solving. Bloom (1976) suggested that affective student characteristics account for approximately 25% of a student's success in a given course; this would explain why many still do well in mathematics regardless of their attitude towards it. Despite feelings of dislike, the value a student places on a course, their study habits, learning style, and degree of motivation contribute significantly to their ability to learn (Bloom, 1976).

Mathematics anxiety is a common condition that makes it difficult for students to concentrate and perform in their computational coursework. Although a bit of anxiety can work to increase academic performance, high levels of anxiety can be debilitating (Nolting, 2002). Tobias (1978) noted that mathematics anxiety is common among adult learners and especially developmental students. Although it varies in intensity, mathematics anxiety is characterized by panic, helplessness and mental paralysis (Tobias, 1978). This disposition certainly affects a portion of the population and can account for a fraction of unsuccessful mathematics students. Nonetheless, because students' attitudes towards mathematics and mathematics anxiety have remained fairly constant over time, they cannot account for the increased need for developmental mathematics that has been noted over the past several decades (Cohen & Brawer, 2008). Instead, some researchers feel that the changes made in mathematics curriculum, pedagogies, and/or course requisites in high school have significantly impacted students' mastery of mathematical concepts (Cohen & Brawer, 2008). Others feel that cognitive abilities, including higher levels of thinking, learning styles, and problem solving abilities, have not been emphasized in the secondary setting and are resulting in poor performance (Chisko, 1985; Newman & Matthews, 1994). Mireles et al. (2011) concurred: students that are weak in mathematical knowledge also lack many of the skills needed for academic success.

There is also a population in community colleges that is predisposed to developmental mathematics and impacts the necessity for the courses. The returning adult learner frequently tests into remedial mathematics. The adult learners may be entering college for the first time or retraining 10, 20, or more years after their high school graduation. Many of these learners find themselves in developmental mathematics when entering higher education because mathematics is a skill that atrophies; if it is not used regularly, it can be forgotten (Bonham & Boylan, 2011).

Regardless of the reason for the high demand of developmental mathematics, colleges are tasked with finding effective ways to address this population. The emporium model of mathematics, corequisite mathematics, supplemental learning strategies, and Carnegie's Statway projects are just a few endeavors that have been touted as tools in reducing the time spent in developmental mathematics (Viadero, 2009). Although these models and others have achieved limited success in certain settings, they have been less successful when scaled up and adopted at other institutions (Bonham & Boylan, 2011). Developmental mathematics continues to be a barrier to degree attainment.

The news is not all bad, however. Many community colleges have evidence suggesting that students do well in their subsequent, program-level mathematical courses once they get through remediation (Aycaster, 2010). A positive correlation also exists when a student can pass a developmental mathematics course on the first attempt. First attempt success is associated with persistence and retention despite the beginning mathematics level of the student (Bahr, 2011). Therefore, a significant goal of developmental mathematics is to produce successful learners upon their first attempt.

Although studies and students have shown that degree completion is attainable for those that begin in developmental mathematics courses, it is important to note that there is still the reality that many students will not make it to college graduation due to the mathematics barrier (Adelman, 1996; Chisko, 1985; Cohen & Brawer, 2008; Mireles et al., 2011; Newman & Mathews, 1994; Nolting, 2002). Despite programming efforts and pedagogies, a portion of the population will not be successful (National Center for Education Statistics, 2010). The reasoning is implied for someone with a high level of dyscalculia and/or other mental deficiencies where limitations do not allow them to negotiate the level of critical thinking and problem solving that college demands. Yet for others, it is much less clear. Institutions and instructors have no way of knowing with certainty who will or will not be successful when confronted with the challenge of learning mathematics (Nolting, 2002). Consequently, the development of effective teaching and learning programs that address all mathematics students can be very difficult.

Student Success Courses

Over the past decade, a number of experimental endeavors have been piloted to support students, set behavioral expectations, and motivate them to succeed in their first year of college and beyond (Barefoot, 2000). Setting the tone for a student's education is especially important at community colleges where a high attrition rate from first to second year exists. Fifty percent of community college students fail to persist, compared to 22% of those at four-year institutions

(Barefoot, 2004). With nearly 50% of all college students now attending two-year institutions, the focus on first-year retention has never been more critical (Complete College America, 2012).

College readiness is not the same as high school completion (Conley, 2007). Conley (2007) noted that in order to be successful, students must be prepared to utilize learning strategies, support mechanisms, and coping techniques much different than those employed in high school. As students head into their first year of college they experience a major shift that requires intervention to ease the transition; the majority of college students cannot successfully navigate the transition on their own (Tinto, 2013). Students who struggle with navigation are at risk for dropping out of college due to frustration, poor decisions, and unforeseen circumstances (Astin, 1984). Tinto (1975) was among the first to study the cause-effect relationship involved in college retention. As a result, he put forth a framework that called for social and academic integration. These measures are intended to be intentional and structured, systemic in nature and coordinated in approach across the institution (Tinto, 2013). By design, Tinto (2013) suggested that the measures include theories of student development, occur early on in the academic experience, demonstrate campus resources, and be centrally coordinated. Additionally, Barefoot (2004) discussed the need for these interventions to be available to all first-year students, not just those deemed at risk of dropping out, because all students need assistance with navigating college. Conley (2007) further substantiated this stating that despite a college's selectivity, new students have difficulty solving problems, evaluating materials, developing arguments, interpreting data, and completing detailed assignments. College readiness is a disposition that goes beyond content knowledge and demonstrates self-awareness (Conley, 2007).

For 90% of American institutions, the need for a common navigational intervention in the first year has translated into some form of a college success course (Barefoot, 2004). College success courses vary in credit length but tend to be composed of several common objectives: time management, study skills, and the use of campus resources such as the library, tutoring, technology, and other support services (Barefoot, 2004). These important experiences provide contextualization of the curriculum and are organized around learning (Tinto, 2013). The psychological changes that follow allow students to transition to the college community and develop a sense of self as student (Tinto, 2013). The academic self-management behaviors taught through college success courses create contextual awareness that is essential for students to know how to interact with each other, staff, and faculty (Conley, 2007). Despite their value, however, few community colleges require a success course for their students.

Student Success Courses and Developmental Mathematics

It has been found that students arrive relatively unprepared for the intellectual demands and expectations of college (Conley, 2007). Conley (2007) noted that the likelihood of students making a successful college transition is a function of their readiness in several key areas including analysis, problem-solving, reasoning, and other related soft skills that promote metacognitive capabilities. He additionally contended that academic self-management behaviors such as time management, study skills, persistence, and awareness of true performance contribute to the success of learners. Likewise, Diseth (2002) found that student success can be predicted if students incorporate study strategies into their learning plan. These aforementioned strategies are typical of the outcomes associated with college success courses. Student success courses contain what Conley referred to as *college knowledge*; the self-awareness and ability of students to interact with their peers, faculty, staff, and academic community in the college environment.

The notion that student success course objectives could raise the completion rates of developmental mathematics learners seems reasonable when you consider that students who test into remedial mathematics coursework consist of a disproportionate numbers of minority and first generation college students (Epper & Baker, 2009). Their opportunity for exposure to the strategies associated with college success is often limited. In general, students in developmental mathematics are less likely to graduate from college and are more likely to take developmental mathematics repeatedly (Mireles et al., 2011). Mireles et al. (2011) looked at promising programs that worked to increase student success among developmental mathematics students on their first course attempt. They observed an intensive summer program that combined developmental mathematics with academic support components including study skills, tutoring, mentoring, and motivation. Their findings indicated that the teaching of learning strategies within the developmental mathematics course had a significant impact on students with high levels of anxiety. Specifically, students recognized that they had the ability to change their attitudes towards mathematics by employing learning strategies and were more successful in the course. Epper and Baker (2009) found similar results in evaluating developmental mathematics programs. Those programs that were the most innovative and successful were complex and combined several instructional and student support strategies.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter discusses the methods used to investigate student course completion success rates in developmental mathematics when a college success course was taken as a corequisite. Of those needing remedial education, developmental mathematics is required of the majority of the students (National Center for Education Statistics, 2010). Additionally, developmental mathematics has one of the lowest course completion rates among two-year institutions (Bahr, 2011). Many curriculum delivery options have been explored within the content area of developmental mathematics but have yielded marginal results (Bonham & Boylan, 2011). This study can help community colleges enhance developmental mathematics completion rates by addressing parameters outside of mathematics course redesign.

Research Questions

This quantitative study questioned the relationship between college student success courses and developmental mathematics course completion. Remedial mathematics taken in conjunction with a student success course provides an enhanced opportunity for mathematics course completion upon the first attempt by providing students with the tools and academic focus required of the endeavor. Developmental mathematics is the most populated course at community colleges, with nearly two-thirds of students requiring it (Adelman, 2006). It is a barrier for students who must complete it in order to move into their major and program-level courses (Bahr, 2011). Less than 50% of students complete developmental mathematics on their first attempt; therefore, it is important to find ways to increase student learning in these courses (Bahr, 2011). In order to determine if the tools associated with college success could reduce the time that students spent in remediation and enhance their academic momentum towards completion of their educational goals, this study addressed the following questions:

1. When a student success course is taken as a corequisite to developmental mathematics, do students perform better in the developmental mathematics course?
2. In looking at the two levels of developmental mathematics in a community college, does a corequisite student success course have a greater impact on one level over another?

In order to address the variable of time since high school graduation (time since exposure to mathematics content), there was a need to ascertain these questions:

3. Does the duration from high school graduation to developmental mathematics course enrollment impact student success in the course?
4. Can a corequisite college success course be used to mitigate any difference found by age in course completion?

Null Hypotheses

The null hypotheses of the study suggested that developmental mathematics students were equally successful as those who simultaneously took a college success and developmental mathematics course. That is, I assumed student success course initiatives were unsuccessful in accomplishing the goal of enhanced developmental mathematics completion rates.

H_o1: There is no statistically significant difference between Level 1 and Level 2 developmental mathematics course completion rates regardless of whether a student success course is taken as a corequisite.

H_o2: There is no statistically significant difference between Level 1 and Level 2 developmental mathematics course completion rates regardless of whether a student success course is taken within one year of taking the developmental mathematics course.

H_o3: Regardless of whether a student success courses is taken as a corequisite, there is no statistically significant difference between the age groups for students' developmental mathematics course (Level 1and Level 2) completion rates.

H_o4: Regardless whether a student success course is taken within one year, there is no statistically significant difference between the age groups of students' developmental mathematics course completion rates in Level 1 and Level 2.

Study Setting

The research was conducted at Valencia College in Orlando, Florida. Valencia was established in 1967, and has since grown to serve a population of nearly 60,000 students. It is the third largest of the 28 community colleges in the Florida system. Valencia serves transfer, technical, economic development, general education, student service, and college preparatory functions through its five locations in Orlando. Primarily, the counties of Orange, Osceola, and Seminole are served. Most of the students reside in Orange County (59%) making it a very urban population (Klingman et al., 2008).

The student population of Valencia is diverse, with an average age of 24. Caucasians compose 36% of the population and 64% are minorities. The largest minority populations are African-Americans (17%) and Hispanics (31%). Student courseload is indicative of a commuter campus. Full-time students are represented by 41.4% of the population. Part-time students are composed of 58.6%. The average courseload is nine credits (Klingman et al., 2008).

Developmental mathematics at Valencia College is housed in the Department of Mathematics. Within the time parameters reviewed in this study, the courses were taught by both adjunct and full-time faculty. Many faculty taught both program and developmental levels of mathematics. For one to be qualified to teach developmental mathematics, a master's degree is required with nine credits specifically awarded in graduate-level mathematics. Student success courses at the college are facilitated by the Division of Learning Support. In order for an instructor to be qualified in this area, he or she must possess a master's degree from an accredited institution. Student success courses were taught by both full- and part-time faculty. The mathematics and student success faculty were trained and assigned to their courses by their individual deans.

At Valencia, students entering the college without ACT or SAT scores must take the state of Florida's Postsecondary Education Readiness Test (Klingman et al., 2008). A student's assessment score indicates which college mathematics course with which they may begin. There are no prerequisite standards for the college success courses at Valencia. Any student can choose to enroll in the college's SLS 1122, three credit, Student Life Skills success course.

Population and Sample

To determine if a college success course taken in conjunction with a developmental mathematics course increased completion rates of students, a causal comparative study was imposed on the representative groups composed at random from the population. The first group consisted of those that completed developmental mathematics prior to, or without taking, a college success course. The second group completed their developmental mathematics coursework while they were simultaneously enrolled in a college success course. A third group included those that completed developmental mathematics after taking a college success course within the past academic year.

To reduce the external threat to validity, the students were selected for study based on their Postsecondary Education Readiness Test (PERT) mathematics scores. Because developmental mathematics in community colleges most often consists of two levels of remediation, the methodology was applied to the Level 1 and Level 2 courses. All Level 1 students in the study scored between 50 and 95 points on the PERT mathematics placement test. Level 2 student scores ranged between 96 and 112 points. These scores indicated how the student performed on the competencies of the PERT exam. A lower score indicated fewer competencies were mastered, and a higher score indicated that the students' basic skills were closer to that of a college freshman.

In addition to PERT mathematics scores, the groups were also comparable due to the common curriculum utilized in the developmental mathematics sections and a common curriculum in the student success sections. In each area, a single department chair assured that faculty training for the course was conducted uniformly. In turn, this facilitated instruction that was common across the department. These measures are strictly adhered to as the College has a rigorous process for assessing student learning outcomes in each discipline. This consistency allows for meaningful data that impacts curricular decisions. Consequently, it is reasonable to anticipate that each student's educational experience in developmental mathematics and each student's experience in student success was similar.

Study Design

Causal comparative analysis was used to predict causation of the disposition in the population. The analysis describes the strength of the relationship among two or more groups based on a single variable. The groups are formed according to an independent variable and compared against the dependent variable post facto. In this study, a *t* test first determined if there was a significant difference between the existing groups. Once statistical significance was established, a Chi-square test of independence and an odds ratio test were used to further provide evidence of a theoretical conjecture of causation or the lack thereof.

Dependent and Independent Variables

Three groups were represented in this study based upon the conditions in which students took their developmental mathematics course. The first group consisted of those who completed developmental mathematics prior to, or without taking, a college success course. The second group completed their developmental mathematics coursework while they were simultaneously enrolled in a college success course. A third group included those who completed developmental mathematics after taking a college success course within the past academic year. The three groups were then further divided according to age and their level of achievement in the developmental mathematics course. Age was based on the duration of the students' time from high school graduation. The first age group was within a few years of high school completion and consisted of students age 20 years or younger. The second age group consisted of students who had been out of school for more than two years, age 21 years or older. Age was an independent variable as well as the PERT score by which students were originally selected. Level of achievement was defined by the categories of pass and other. In developmental mathematics, *passing* was indicated by a final grade of A, B, or C. *Other* was defined as a final grade of D, F, or W. Withdrawals were included in the study because the students did not successfully complete the course. Consequently, the indicator was *other* as opposed to *fail*. The achievement level of pass or other was the dependent variable.

Procedures and Data Collection

In a causal comparative study the analysis is a comparison of the differences that exist among groups. The analysis is done post facto meaning that the characteristics and phenomena being studied have already occurred; the groups are pre-existing. For these reasons, no specific instrumentation was used in this study. Data were drawn from the institution's student record system with the requisite approval from the college's Institutional Review Board. Data collection consisted of sorting information and drawing from the applicable fields in the student record system. It was expected that the data from one to two academic years would be large enough in size and scope to establish meaningful results and this did transpire accordingly.

Data Analysis

The statistics used to compare the casual comparative groups in both Level 1 and Level 2 of developmental mathematics consisted of three methodologies in order to triangulate the results.

1. For each of the three sample groups taking developmental mathematics (one with no college success course, one with a college success course, and one with a college success course within the preceding year) a *t* test determined if there was a significant difference between the course success rates and, additionally, the success rates of the age subgroups within.
2. A Chi-square test of independence was done. This assessment further substantiated the findings of associations in the study by comparing actual outcomes to those statistically

expected. Significance indicated a positive relationship between the age groups and the success of mathematics students during and/or after an SLS course.

3. An odds ratio test was performed to further substantiate the findings. The tables portray the relationships found between the categorical variables of age, achievement and course sequence.

Measurement

If significance was found to exist among the sample groups, a discriminant function analysis was to be considered. This analysis, though weak, provides a method to predict what the success rate (achievement level) might be if a person belongs to a specific age group and participates in a certain combination of courses (a developmental mathematics course only/a college success course with a developmental mathematics course/a college success course within one year preceding a developmental mathematics course). Ultimately, however, the appropriate type of data were not available to further make predictions in this study.

Summary

This chapter elaborated on the design of the research project. The population was identified as well as the subgroups within for demographic analysis. Methodology was detailed and included the specific statistical tests that were used in the causal comparative analysis. A data collection process also emerged. Findings from this research project and further discussion are presented in Chapters 4 and 5 of the dissertation.

CHAPTER 4

DATA ANALYSIS

The purpose of this study was to determine if a student success course dedicated to study skills, college navigation, career exploration, and personal discovery could improve the success rate of developmental mathematics students when taken as a corequisite to their remedial mathematics course. The implications of the research provide a unique opportunity to address the large number of students and low pass rates in developmental mathematics sequences through a curriculum other than mathematics. The study had the following objectives:

1. To identify if a student performs better in developmental mathematics when a student success course is taken as a corequisite.
2. To investigate if a corequisite student success course has a greater impact on one level over another when looking at the two levels of developmental mathematics in a community college.
3. To ascertain if the duration from high school graduation to developmental mathematics course enrollment impacts student success.
4. To examine if a corequisite college success course could be used to mitigate any difference found by age in course completion.

These objectives served as the guiding principles in addressing four primary research questions:

1. When a student success course is taken as a corequisite to developmental mathematics, do students perform better in the developmental mathematics course?
2. In looking at the two levels of developmental mathematics in a community college, does a corequisite student success course have a greater impact on one level over another?

In order to address the variable of time since high school graduation (time since exposure to mathematics content), there was a need to ascertain these questions:

3. Does the duration from high school graduation to developmental mathematics course enrollment impact student success in the course?
4. Can a corequisite college success course be used to mitigate any difference found by age in course completion?

To report the findings of this research, several statistical analytics were demonstrated in hopes of identifying relationships between the variables. Descriptive measures were calculated to assess the magnitude of the effect and then inferential techniques were utilized in order to generalize the results to a larger population. More specifically, a *t* test, Chi-square analysis of independence and an odds ratio test were used to determine significance in the associations. A discriminant function analysis did not occur as suggested in Chapter 3 despite findings of significance because the specific scores of the learners in the population were not available to conduct such calculations and there was no way to ascertain those values in the post facto student record system of the College.

Demographic Characteristics

This research was conducted at Valencia College in Orlando, Florida. In developing the study, it was necessary to acquire information that portrayed the students' age, incoming college assessment scores, and disposition in a student success course at the institution of study. These attributes were sorted by field in the student records system by the Department of Institutional Research at Valencia. Early in the collection process, an inconsistency was noted that had the potential to limit the results of the study. In recent years, the majority of the students in the College's SLS college success course had been mandated into the class based on their need for developmental courses. Students who assessed into developmental reading, writing, and mathematics were required to take SLS. This resulted in the recent course sections primarily being populated with students in need of extensive remediation. This study was not intended to focus on a mandatory success course for multi-deficient developmental learners but on a course that was provided to the general population. Therefore, it was necessary to go back in the history of the College to the point where SLS was not mandated and was available to the general population. There was no difference in the curriculum of the two points in time, but the learners' potential for achievement in the non-mandatory course was more randomized. The data reflect the corresponding academic year of 2005 to 2006.

In total, 6,160 students were included in the data pool. As shown in Table 1, the ages were categorized based on the duration of time from high school graduation as a general indicator of the length of time since exposure to mathematics content. Those within a few years of graduation were categorized as age 20 or younger, with the other group containing the remainder of individuals, age 21 or older. There were 3,803 recent high school completers and 2,357 representing three or more years beyond high school graduation. According to course sequence, as seen in Table 2, 4,903 students in the study took developmental mathematics only, 1,015 took developmental mathematics while taking the SLS course, and 242 took developmental mathematics within a year after taking SLS.

Table 1

Distribution of Participants by Age

Age	Frequency (n)	Percent (%)
20 Years or Younger	3,803	61.73
21 Years or Older	2,357	38.26

Table 2

Distribution of Participants by Course Sequence

Sequence	Frequency (n)	Percent (%)
Development Math Only	4,903	79.59
Development Math with SLS	1,015	16.48
SLS Within Year Prior to Math	242	3.93

As shown in Table 3, students were further grouped according to their mathematical proficiency. This was based on the level of developmental mathematics they assessed into when they took their PERT college placement test. At Valencia College, those who scored 50-95 points on the assessment placed into the lowest level of developmental mathematics, MAT 0012. Those obtaining 96-112 points were enrolled in the higher developmental level, MAT 0024, course. In the population, 3,140 students placed into MAT 0012 and 3,020 were MAT 0024 learners.

Table 3

Distribution of Participants by Developmental Mathematics Course Placement

Course	Frequency (n)	Percent (%)
MAT 0012	3,140	50.97
MAT 0024	3,020	49.03

Within their mathematics placement, students were subdivided based upon their performance in the course. Initially, a pass/fail designation was used to indicate those who did and did not successfully complete their mathematics course upon the first attempt. Later, it was determined that the data should also include those who self withdrew (W) from the course as well as those who were administratively withdrawn. An administrative withdrawal is designated by a grade of WF, meaning the student was failing and did not complete the course; therefore, the instructor withdrew him or her. In both the W and WF grade conditions, students were unsuccessful. Thus, these grades were deemed equally important in the data pool as those receiving a grade of F. Consequently, in Table 4 through Table 9 the fields are labeled Pass/Other as opposed to Pass/Fail. Tangent to those who were unsuccessful in mathematics, those who were successful in mathematics include grades of A, B, and C. A completion grade of C or better is a typical requirement in successfully passing developmental mathematics courses at community colleges, including Valencia College. Table 4 and Table 5 delineate these success rates by developmental mathematics course and by age.

Table 4

Distribution of Participants by Developmental Mathematics Course Success

Course	Pass (n)	Percent (%)	Other (n)	Percent (%)
MAT 0012	1,896	60.38	1,244	39.61
MAT 0024	2,151	71.22	869	28.77

Table 5

Distribution of Participant Success by Age

Age	Pass (n)	Percent (%)	Other (n)	Percent (%)
20 Years or Younger	2,454	64.52	1,349	35.47
21 Years or Older	1,593	67.58	764	32.41

Tables 6 through 13 outline the outcomes of student mathematics course achievement according to the sequence in which the students took their classes. The sequences are defined as those who took developmental mathematics before SLS, developmental mathematics during SLS, and developmental mathematics after taking SLS but within one year prior. Because I was interested in determining if students possessed transferable knowledge, only those who successfully completed the SLS course were included in the study. The criteria for passing the SLS course included grades of A, B, C, and D.

Table 6 and Table 7 show the overall developmental mathematics course success of students based upon their age groups. This differentiates success based upon the duration of time they have been out of high school and entered college. It includes learners who tested into MAT 0012 as well as MAT 0024.

Table 6

Distribution of Participant Success by Course Sequence at Age 20 Years or Younger

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	1,659	58.43	1,180	41.56
Math During SLS	662	83.90	127	16.09
Math After SLS	133	76.00	42	24.00

Table 7

Distribution of Participant Success by Course Sequence at Age 21 Years or Older

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	1,349	65.35	715	34.64
Math During SLS	200	88.49	26	11.50
Math After SLS	44	65.67	23	34.32

Tables 8 through 10 indicate how students did in the MAT 0012 developmental course by sequence. Table 8 is a composite of all MAT 0012 learners in their sequences. Table 9 and Table 10 are broken out by age and include the success of MAT 0012 student sequences by age 20 years or younger and 21 years or older.

Table 8

Distribution of Participants by MAT 0012 Success and Course Sequence

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	1,428	55.95	1,124	44.04
Math During SLS	412	83.40	82	16.59
Math After SLS	56	59.57	38	40.42

Table 9

Distribution of Participants by MAT 0012 Success Age 20 Years or Younger

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	656	50.97	631	49.02
Math During SLS	276	81.17	64	18.82
Math After SLS	31	62.00	19	38.00

Table 10

Distribution of Participants by MAT0012 Success Age 21 Years or Older

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	772	61.02	493	38.97
Math During SLS	136	88.31	18	11.68
Math After SLS	25	56.81	19	43.18

Tables 11 through 13 indicate how students did in the MAT 0024 developmental course by sequence. Table 11 is a composite of all MAT 0024 learners in their sequences. Table 12 and Table 13 are broken out by age and include the success of MAT 0024 student sequences by age 20 years or younger and 21 years or older. Note the lower number of participants who fell into the categories associated with Table 13. Despite the large number of participants in the population of the study, these subgroups were under represented.

Table 11

Distribution of Participants by MAT 0024 Success and Course Sequence

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	1,580	67.20	771	32.79
Math During SLS	450	86.37	71	13.62
Math After SLS	121	81.75	27	18.24

Table 12

Distribution of Participants by MAT 0024 Success Age 20 Years or Younger

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	1,003	64.62	549	35.37
Math During SLS	386	85.96	63	14.03
Math After SLS	102	81.60	23	18.40

Table 13

Distribution of Participants by MAT 0024 Success Age 21 Years or Older

Sequence	Pass (n)	Percent (%)	Other (n)	Percent (%)
Math Before SLS	577	72.21	222	27.78
Math During SLS	64	88.88	8	11.11
Math After SLS	19	82.60	4	17.39

Descriptive Analysis

To investigate any potential relationships, multiple correlation analyses were conducted utilizing *t* tests, Chi-square tests of independence and odds ratio tests. First, the study assessed and compared the performance of each age group, 20 years or younger and 21 years or older. There was interest in knowing if those under 20 years of age and those over 21 years of age did equally well in their developmental mathematics courses speculating that the duration from high school may have had an influence on achievement. Additionally, there was interest in knowing if the age groups performed differently when participating in the same sequence (developmental mathematics before, during or after SLS). Next, I looked at the effect of the SLS course to determine if taking developmental mathematics before, during or after but within one year of an SLS course had any effect on developmental mathematics achievement. This analysis was done for each developmental mathematics course of MAT 0012 and MAT 0024 as well as for the combined developmental mathematic courses.

Age Effect

When mathematics was taken before SLS in MAT 0012 (Table 14), there was a higher proportion of success for students 21 years of age or older compared to age 20 years or younger.

The difference was highly significant ($p < .001$). When MAT 0012 was taken during SLS, the proportion of success in the age group 20 years or younger was lower than that in the age group 21 years or older. The difference was statistically significant at the .10 level but did not show significance at the .05 level ($p = 0.059$). When MAT 0012 was taken after SLS but within the same year, the proportion of success in age group 20 years or younger was higher than those age 21 years or older, but the difference was not statistically significant ($p =.350$). These findings suggest that students taking MAT 0012 before SLS in the 21 years or older age group completed MAT 0012 more often than students 20 years of age and under.

Table 14

Age Group Comparison of Success in MAT 0012 by Course Sequence

Facet	20 Years or Younger (%)	21 Years or Older (%)	*p*
Math Before SLS	50.97	61.02	.001**
Math With SLS	81.17	88.31	.059
Math After SLS	62.00	56.81	.350

**$p < .001$, one-tailed.

Table 15 demonstrates a similar pattern in MAT 0024. When mathematics was taken before SLS, there was a higher proportion of success for students age 21 years or older compared to students age 20 years or younger. The difference was statistically significant ($p < .001$). When MAT 0024 was taken during SLS, the proportion of success in age group 20 years or younger was lower than that in age group 21 years or older, but the difference was not significant ($p = .319$). When MAT 0024 was taken after SLS but within the same year, the proportion of success in age group 20 years or younger was slightly lower than those in age 21 years or older, but the difference was not statistically significant ($p = .396$). These findings suggest that students age 21 years or older successfully completed MAT 0024 more often when mathematics was taken before SLS than students 20 years of age and younger, and that they also had a higher percentage of success in the other two sequences in this sample.

Table 15

Age Group Comparison of Success in MAT 0024 by Course Sequence

Facet	20 Years or Younger (%)	21 Years or Older (%)	*p*
Math Before SLS	64.62	72.21	.001**
Math With SLS	85.96	88.88	.319
Math After SLS	81.60	82.60	.396

**$p < .001$, one-tailed

Table 16 portrays an age group comparison of students regardless of the developmental mathematics course in which they were enrolled. When mathematics was taken before SLS, there was a higher proportion of success for students age 21 years or older compared to those age 20 years or younger. The difference was statistically significant ($p < .001$). When mathematics was taken during SLS, the study determined that the proportion of success in age group 20 years or younger was lower than that of age group 21 years or older. The difference was statistically significant at the .10 level but was not significant at the .05 level ($p =.094$). When mathematics was taken after SLS but within the year, the proportion of success in age group 20 years or younger was higher than those age 21 years or older, but the difference was not statistically significant ($p = .107$). The study suggests that students in the 21 years or older age group did better in developmental mathematics before SLS than those 20 years of age or younger when taking either MAT 0012 or MAT 0024.

Table 16

Age Group Comparison of Success in Mathematics Courses Combined

Facet	20 Years or Younger (%)	21 Years or Older (%)	*p*
Math Before SLS	58.43	65.35	.001**
Math With SLS	83.90	88.49	.094
Math After SLS	76.00	65.67	.107

**p < .001, one-tailed

In general, we can ascertain that students age 21 years or older did better than their younger counterparts when they took a developmental mathematics course without a student success course. No difference in course completion was found between age groups when mathematics was taken with SLS. Additionally, no difference in passing the course was found between age groups when students took developmental mathematics after a student success SLS course. However, the percentages seemed to indicate that students in both age groups of this sample did better when an SLS course was among their sequence. This data suggests that students age 20 years or younger may enhance their developmental mathematics achievement if they take an SLS course simultaneously to or within a year prior of their developmental mathematics course as opposed to taking mathematics before SLS. Further statistical analyses in this study appear to support this premise.

Having identified areas of significance in the success levels of developmental mathematics by age, the results were statistically triangulated to cross-reference findings and identify any further potential associations. Further analyses were first conducted by applying a Chi-square test of independence (Table 17). The null hypothesis assumed that the variables of age and developmental mathematics achievement (combined MAT 0012 and MAT 0024) were independent. In our sample $p < .001$ which resulted in the null hypotheses being rejected. The Chi-square analysis produced the same conclusion as the results of the *t* tests; it is likely that developmental mathematics achievement and age are associated. More specifically and assuming generalizability of the findings of this study, students in group age 21 years or older do better in developmental mathematics.

Table 17

Observed and Expected Frequencies of Success by Age

	20 Years or Younger			21 Years or Older		
Facet	Observed	Expected	Deviation	Observed	Expected	Deviation
MBS	1659	1823.98	14.92	1349	1184.02	22.99
MDS	662	522.70	37.13	200	339.30	57.19
MAS	133	107.33	6.14	44	69.67	9.46

Note. MBS = mathematics before SLS; MDS = mathematics during SLS; MAS = mathematics after SLS. $\chi 2 = 147.83$, $df = 2$, $p < .001$.

Next, an odds ratio test was conducted to look at the differences in achievement by age. The odds ratio test determines the chances an outcome has of occurring when it is exposed to a particular condition. For this analysis, the study was interested in the age groups' course outcomes when mathematics was taken alone and when developmental mathematics was taken either during or within a year of a student success course. Table 18 provides the odds of success in the mathematics alone and mathematics with exposure to SLS sequences. Similar to earlier findings, students in the 21 years or older age group have higher odds of completing their course when they take mathematics alone. When an SLS course is introduced either during or within one year prior to developmental mathematics the achievement odds of both age groups (20 years or younger and 21 years or older) are increased. Further, the odds in each age group increase in a way that put the two groups closer to achieving the same completion rates.

Table 18

Odds Ratios by Age and Course Sequence in Combined Mathematics Courses

	20 Years or Younger	21 Years or Older
Math Before SLS	1.41	1.89
Math With Any SLS	4.70	4.98

SLS Effect

In addition to the success rates of students by age, the study investigated the effect an SLS course had on student achievement in Level 1(MAT 0012) and Level 2 (MAT 0024) developmental mathematics. Analyses were conducted based on three comparisons: mathematics before and mathematics during SLS, mathematics before and mathematics after SLS, and mathematics before with combined figures from mathematics during and mathematics after SLS (exposure to SLS). These analytics were completed by age groups for MAT 0012, MAT 0024, and the courses and ages combined to investigate if SLS had a greater impact in one developmental mathematics course over the other and to see if results could be generalized to the developmental mathematics population.

Table 19 shows the results of the tests of proportions (*t* tests) in MAT 0012 that checked for differences in achievement when mathematics before SLS was compared to mathematics during and/or after SLS. The proportion of success for students age 20 years or younger in mathematics with an SLS course was highly significant ($p < .001$). Mathematics during SLS was also found to be significant ($p < .001$) in the 21 years or older age group when compared to those who took mathematics without an SLS course. When the age groups were combined, significance ($p < .001$) was present when students took mathematics during SLS compared to mathematics without an SLS course. Consequently, the study provides evidence that students who took mathematics with an SLS course had significantly higher rates of success in their MAT 0012 course than those that did not take SLS.

The same outcomes did not occur when MAT 0012 before SLS was compared to MAT 0012 after SLS. In each age group the results were not significant when the proportions of student achievement were compared. However, when mathematics before SLS was compared to mathematics with or after SLS (SLS exposure) students' age 20 years or younger achievement results were highly significant ($p < .001$). Students' results in age group 21 years or older were also significant ($p < .001$). Additionally, in the combined age groups, students who took SLS during or after their developmental MAT 0012 course had a proportion of success that was highly significant ($p < .001$). In MAT 0012, students who took mathematics with or after an SLS course completed their developmental mathematics course more frequently than students who took mathematics without a student success course.

Table 19

Comparison of Mathematics Before SLS to Other Course Sequences in MAT 0012

Facet	Math With SLS	Math After SLS	Math With or After SLS
20 Years or Younger	.001**	.243	.001**
21 Years or Older	.001**	.682	.001**
Combined Ages	.001**	.620	.001**

**$p < .001$, two-tailed

Table 20 shows the results of the tests of proportions in MAT 0024 that checked for differences in achievement when mathematics before SLS was compared to mathematics during and/or after SLS. The proportion of success for students age 20 years or younger in mathematics with an SLS course was shown to be highly significant ($p < .001$). Mathematics during SLS was also significant ($p = .002$) in the 21 years or older age group when compared to those who took mathematics without an SLS course. However, the results showed a lower level of significance than those taking MAT 0012. When the age groups were combined, significance ($p < .001$) was present when students took mathematics during SLS compared to mathematics without an SLS course. Consequently, the study provides evidence that students who took mathematics during an SLS course had significantly higher rates of success in their MAT 0024 course than those that did not take SLS.

Contrary to the results in MAT 0012, an effect was noted when certain students took MAT 0024 after SLS. Students age 20 years or younger did significantly better ($p < .001$) in MAT 0024 when they had taken the mathematics course after, but within one year of SLS. The group age 21 years or older did not, however, show any change in mathematics course completion rates despite taking SLS within the year. When age groups were combined the proportion of student achievement in mathematics was significant ($p < .001$) when students took MAT 0024 after SLS.

When MAT 0024 before SLS was compared to MAT 0024 with or after SLS (SLS exposure), students' age 20 years or younger mathematics achievement results were highly significant ($p < .001$). Students' results in age group 21 years or older were also significant ($p < .001$). Additionally, in the combined age groups, students taking SLS during or after their developmental MAT 0024 course had a proportion of success that was highly significant ($p <$

.001). In MAT 0024, students who took mathematics with or after an SLS course completed their mathematics course more frequently than students who took mathematics without a student success course.

Table 20

Comparison of Mathematics Before SLS to Other Course Sequences in MAT 0024

Facet	Math With SLS	Math After SLS	Math With or After SLS
20 Years or Younger	.001**	.001**	.001**
21 Years or Older	.002*	.435	.005*
Combined Ages	.001**	.001**	.001**

**p* < .05, ***p* < .001, two-tailed

In Table 21 the developmental mathematics courses of MAT 0012 and MAT 0024 were combined to get an overall disposition of student achievement in developmental mathematics in conjunction with SLS. The proportion of success for students age 20 years or younger in any developmental mathematics with an SLS course was highly significant ($p < .001$). Developmental mathematics during SLS was also significant ($p < .001$) in the 21 years or older age group when compared to those who took mathematics without an SLS course. When the age groups were combined, significance ($p < .001$) was present when students took any developmental mathematics course during SLS compared to mathematics without an SLS course. Consequently, the study provides evidence that students who took either developmental mathematics course during an SLS course had significantly higher rates of success in their mathematics course than those that did not take SLS.

Students age 20 years or younger did significantly ($p < .001$) better in developmental mathematics when they took mathematics after, but within one year of, SLS. The group age 21 years or older did not show any change in developmental mathematics course completion rates despite taking SLS within the year. When age groups are combined the proportion of student achievement in developmental mathematics was significant ($p < .001$) when students took mathematics after SLS.

When the developmental mathematics courses before SLS were compared to mathematics with or after SLS, students' age 20 years or younger mathematics achievement results were highly significant ($p < .001$). Students' results in age group 21years or older were also significant ($p < .001$). Additionally, in the combined age groups, students taking SLS during or after their developmental mathematics course had a proportion of success that was highly significant ($p < .001$). In developmental mathematics, students who took mathematics with or after an SLS course completed their mathematics course more frequently than students who took mathematics without a student success course regardless of their age.

Table 21

Comparison of Math Before SLS to Other Course Sequences in MAT 0012 and MAT 0024

Facet	Math With SLS	Math After SLS	Math With or After SLS
20 Years or Younger	.001**	.001**	.001**
21 Years or Older	.001**	.797	.001**
Combined Ages	.001**	.001**	.001**

**$p < .001$, two-tailed

Having identified areas of significance in the success levels of developmental mathematics by SLS sequence, results were triangulated to cross-reference findings and identify any further associations. Further analyses were conducted by applying a Chi-square test of independence (Table 22). This test was used to determine if there was an association between the two variables of mathematics achievement and a student success course. The null hypothesis assumed that these variables were independent. In our sample $p < .001$ which resulted in the null hypotheses being rejected. The Chi-square analysis of independence produced a similar conclusion to that resulting from the *t* tests; it is likely that mathematics achievement is associated with SLS. Students who took an SLS course during or within one year prior to mathematics completed their developmental mathematics coursework more often than those who took developmental mathematics alone.

Table 22

Observed and Expected Frequencies of Success in Any SLS Sequence

	20 Years or Younger			21 Years or Older		
Facet	Observed	Expected	Deviation	Observed	Expected	Deviation
MBS	1659	1823.98	14.92	1349	1184.02	22.99
MAnyS	795	630.02	43.20	244	408.98	66.55

Note. MBS = mathematics before SLS; MAnyS = mathematics taken in any sequence with SLS. $\chi 2 = 147.66$, $df = 2$, $p < .001$.

Next, an odds ratio test was conducted to look at differences in developmental mathematics achievement by course among learners that did and did not take SLS. For this analysis, the study was interested in the outcome of mathematics achievement when developmental mathematics (MAT 0012 and MAT 0024) was taken alone and when learners were exposed to a student success course during or within one year of mathematics. Table 23 provides the odds of success in developmental mathematics by course. Similar to the findings in the *t* test analysis and Chi-square test for independence, students had higher odds of completing their developmental mathematics course when a student success course was taken in sequence with the mathematics course.

Table 23

Odds Ratio by Developmental Mathematics Course and Combined Ages

	MAT 0012	MAT 0024
Math Before SLS	1.27	2.05
Math With Any SLS	3.90	5.83

Research Question 1

In order to ascertain if a student performs better in developmental mathematics when a student success course is taken as a corequisite, the study explored associations between developmental mathematics achievement and SLS course sequence. The comparison was further delineated by age.

When looking at the overall performance of students in their developmental mathematics course, the study found that there was significance in the difference of performance of those who took a mathematics course and an SLS course at the same time. Students who took their developmental mathematics course during an SLS course successfully completed their mathematics course more often than students taking mathematics alone. By age group, both 20 years or younger and 21 years or older showed a significant response in achievement when an SLS course was taken during their mathematics course. Those age 20 years or younger, however, were more positively influenced by SLS and produced greater differences in success than those age 21 years or older taking SLS during developmental mathematics.

Research Question 2

In MAT 0012 and MAT 0024 there was interest in knowing if developmental mathematics with SLS could be more useful in one mathematics course than the other. The study indicated that there were differences in the effect SLS had on individual course achievement. The magnitude of the effect varied depending on the level of the developmental mathematics course and age of the student.

In the lower level MAT 0012 course, significance in achievement was found for each age group when the mathematics course was taken with SLS. Taking MAT 0012 with a student success class positively impacted all learners equally. If a student took MAT0012 with a student success class his or her level of achievement in mathematics increased.

In MAT 0024, those who took SLS with their mathematics course did significantly better than those taking mathematics alone, but age group 21 years or older showed significance at the .05 level (p = .002) where age group 20 years or younger and the combined ages showed a proportion of increased achievement at the level of .001.

In answering Research Question 2, it appears that mathematics during SLS was very beneficial for learners in both MAT 0012 and MAT 0024. Additionally, the study found that learners participating in any SLS option did better in both MAT 0012 and MAT 0024. The two courses do differentiate, however, in achievement results when students took mathematics after SLS. If students are taking mathematics after SLS, results indicate that those in MAT 0024 did better than those in MAT 0012 under the same conditions.

Research Question 3

It has been noted that mathematics is a skill that atrophies (Bonham & Boylan, 2011). This study was interested in seeing if that that theory held true for the individuals in MAT 0012 and MAT0024. More specifically, did the duration from high school graduation to developmental mathematics course enrollment impact students' success in their developmental mathematics course? The structure of the study was designed to depict short-term and long-term duration from high school completion through the division of students into two categorical age groups. By analyzing the success rates of each group, the theory of mathematics atrophy could be explored. The mathematics success rates of students age 21 years or older and those age 20 years or younger were compared for MAT 0012 and MAT 0024 based upon the condition in which the students took their mathematics course (mathematics before SLS, mathematics with SLS, and mathematics after SLS).

Interestingly, the only potential for atrophy found was when MAT 0012 was taken after SLS. However, this difference was not significant ($p = .350$). Overall, students age 21 years or older did better than their younger counterparts when they took a developmental mathematics course despite the SLS sequence or developmental mathematics level. Significance was found in MAT 0012 ($p < .001$) and MAT 0024 ($p < .001$) when mathematics was taken before SLS. No difference in course completion was found between age groups when mathematics was taken in combination with SLS. Because the older groups of students were shown to complete their mathematics courses at a higher rate, this suggests that time from high school graduation does not impact course performance in developmental MAT 0012 or MAT 0024. Although educators may think that coming back to school after a gap causes mathematics success rates to decline, these data do not support that.

Research Question 4

Because older students tended to do better in mathematics despite being out of high school for a while, Question 4 was interested in determining if a corequisite college success course could be used to mitigate these differences. As seen in Table 19 and Table 20, results indicate that these differences can be mitigated. Students age 20 years or younger who took MAT 0012 or MAT 0024 with a corequisite SLS course increased their mathematics completion rates significantly. Further, the odds ratio test (Table 23) provides evidence that the gap in achievement between the two age groups is closed when an SLS course is present in the sequence.

CHAPTER 5

DISCUSSION OF FINDINGS

This study investigated the achievement levels of developmental mathematics learners focusing on the relationship of a student success course taken in combination with developmental mathematics. A causal comparative analysis was completed to determine any differences that existed by age, level of the mathematics course, and the sequence in which students took an SLS success course with their developmental mathematics. In generalizing the study, the research was designed to ascertain if community college developmental mathematics course completion could be enhanced by a corequisite student success course.

In order to investigate achievement in developmental mathematics when an SLS course was taken, a post facto study was conducted at Valencia College in Orlando Florida. The quantitative study was analyzed using several statistical analyses that included a t test, Chi-square test of independence, and an odds ratio test. This chapter provides a discussion of the statistical findings, implications of the research, recommendations for further study, and summative comments. Discussion and interpretations of the findings are provided in accordance with the general effects investigated in the study. Age and mathematics course sequence with SLS were the two primary effect areas evaluated. Further analysis in each effect area was conducted to determine if there were any potential differences when these attributes were associated with the lower level developmental MAT 0012 compared to that of the secondary level developmental MAT 0024.

Age Effect

According to the quantitative evidence in Chapter 4, age is associated with mathematics achievement when students take developmental mathematics before taking a student success course. Students in the group 20 years or younger performed differently in developmental mathematics than those in the 21 years or older age group. More specifically, the study found that the age group 21 years or older was significantly positively correlated to developmental mathematics course success when mathematics was taken without an SLS corequisite. This suggests that when mathematics is taken alone, developmental mathematics students who have been out of high school for more than a few years do better in mathematics than those who came into college directly from high school. This finding does not support the claims of Bonham and Boylan (2011) suggesting that mathematics is a skill that atrophies. On the other hand, this study must take into consideration that the courses being analyzed are remedial in nature. Therefore, it is possible that despite older learners achieving at a higher rate in developmental mathematics in this study, some atrophy may still have occurred in causing them to initially place into a developmental mathematics course. It could also be that the students' enhanced maturity has established a greater sense of responsibility and commitment to success in the course (Bronfenbrenner, 2005).

In this study, when a student success SLS course was introduced either during or prior to the students' developmental mathematics course, the age groups did not exhibit any comparable differences in their MAT 0012 or MAT 0024 course success. When development mathematics was taken during or after SLS the age groups were negatively correlated to achievement.

Overall, the percent of success in each age group was greater, but there was no significant difference between those age 20 years or younger and 21 years or older. This finding suggests that those in age group 20 years or younger benefitted in mathematics when the variable of SLS was introduced and that it closed the gap in success between the age groups. In most instances, age group 21 years or older still performed a few percentage points better in MAT 0012 and MAT 0024. An exception, however, occurred when age group 21 years or older took developmental MAT 0012 after, but within one year of, SLS. In this sequence, the older group of students completed the course several percentage points below the completion rate of the 20 years or younger age group. This suggests that a student success course may contribute differently to the success of those age 21 years or older when they are taking the lower level MAT 0012 course. It may be that those in the older group receive little or no benefit to mathematics success when SLS is taken within a year prior to MAT 0012. There is also the potential that those age 20 years or younger receive a disproportionately greater benefit when taking MAT 0012 after SLS. Or these differences may simply be skewed based upon the smaller number of learners age 21 years or older taking mathematics after SLS in the population.

SLS Effect

Although the effect age had on achievement was an important component of this study, the primary purpose of the investigation was to determine if there was a student success course (SLS) effect. The SLS effect is the magnitude of the developmental mathematics course completion correlation present when a student success course is taken within one year prior to or during enrollment in a developmental mathematics course. More specifically, the investigation was designed to determine if student success courses were effective corequisites to developmental mathematics in the community college. In the event of a positive correlation, it was hoped that the evidence could then be used to address the developmental mathematics high enrollment/low completion rates in community colleges across the country.

Indeed, there was a significant positive correlation found when students took mathematics and an SLS course at the same time or when an SLS course was taken within one year prior to mathematics. Students who participated in these sequences passed their MAT 0012 and MAT 0024 developmental mathematics courses at significantly higher rates. The magnitude of the difference in achievement between mathematics alone and mathematics with or after SLS was significant for both of the age groups. However, specific age group findings in the mathematics after SLS sequence resembled data noted in the age effect analysis for the group age 21 years or older. No significance was noted when students age 21 years or older took their mathematics course after SLS when compared to those in the same group taking mathematics without a student success course. These results were somewhat surprising given that significance was found in every other combination of age and sequence of SLS. After further investigation, however, it was noted that the age group 21 years or older taking mathematics after SLS, had a sample size that was considerably smaller than other categories. Earlier findings discussed in the age effect of MAT 0012 pointed to this disposition. In MAT 0012 after SLS, course completion percentages in age group 21 years or older decreased when all other age and sequence combinations increased. This was the only area in the data where this occurred; all other percentages increased. This suggests that something different is occurring within the population and the plausible rationalization of an inadequate sample size for the category. In MAT 0012 there were only 25 students in the entire sample of 6,160 students who met this condition. Likewise, MAT 0024 had 19 students in this category. Even though the overall sample size of the study was appropriate (6,160), the age group of 21 years or older in the mathematics after SLS sequence was far less represented (44) than the age group of 20 years or younger students in the same category (522). This was the only area of the study noted as disproportionate. Consequently, the result of no increase in the completion percentage of the 21 years or older age group taking mathematics after SLS may not be a reliable indicator and should probably not be considered as such. A larger sample in this age and sequence could produce a different result, including the increase in the percentage of success that is more reflective of the patterns seen in the study.

Even though the combined results of mathematics during or mathematics after SLS produced a significant increase in the mathematics achievement of students, there were differences in each developmental mathematics course when mathematics was taken after SLS. In MAT 0012, no significance was found in either age group when students took mathematics after SLS compared to taking mathematics alone. This was not the case in MAT 0024, where the combined ages indicated significance in achievement in the mathematics after SLS sequence. It appears that there is something more specific to the MAT 0012 condition of mathematics after SLS. The results suggest that those in deep mathematics remediation greatly benefit when an SLS course is taken at the same time as their MAT 0012 course. This could be due to a more immediate need for study skills and orientation to college success. This disposition is often referred to as *just in time learning* and was borrowed from industry in referring to communication and resources provided when they were needed most (Riel, 1998). Mathematics achievement is not significantly impacted when mathematics is taken after SLS in MAT 0012, perhaps because the transfer of knowledge from SLS is not on par with the level of support needed. Conversely, in MAT 0024, students greatly benefit when they take mathematics with

SLS or mathematics after SLS. The second level of remediation is conducive to just in time support and also perpetuates knowledge transfer of SLS skills after the fact.

Implications

Prior to this study, very little evidence existed on the correlation of student success courses with various disciplines. Additionally, developmental mathematics improvement was often detailed in research associated with pedagogical changes and content strategies in the classroom. This study provides a unique perspective and evidence to suggest that developmental mathematics in itself is not broken and does not need to be fixed through endless changes in delivery and format (Nolting, 2002). Current initiatives such as the emporium model, Statway, cohort learning, and the myriad of other models may not be the answer to achieving higher success rates in developmental mathematics. Instead, this study's findings suggest that it is possible to increase developmental mathematics achievement by incorporating parameters that are uniquely separate from the course and its content.

The evidence in this study could be used in a variety of ways. First, when students test into developmental mathematics in a community college, a student success course could be required in order to enhance any given student's chance of mathematics course completion. For students that test into deep mathematics remediation and require both level one and level two, a student success course should be a mandatory corequisite in order to provide them with just in time learning support. If a student places into the second level of mathematics just below that of program level, a student success course could enhance his or her achievement by being required as a prerequisite or corequisite to the mathematics class.

Second, the study could be used to determine the courses a student takes in their first term. Adelman (2006) suggested that an undergraduate's early course load and subsequent success are instrumental in degree completion. He defined this as academic momentum. Students that progress through their coursework at a given pace are more likely to achieve their educational goals than students that progress slowly through their paths. Attewell et al. (2012) further substantiated this claim in noting that students that take and pass a full load of college credits early on tend to take and be successful in the same manner in subsequent terms. Consequently, academic momentum holds value for the developmental student. This study has identified a pathway that may enhance developmental mathematics students' ability to complete their mathematics course successfully on the first attempt. That success is facilitated by a corequisite student success course. For this population of students, the momentum achieved could theoretically enhance degree completion as well. By selecting developmental mathematics and a student success course in the first term, the early course completion Adelman espoused in producing academic momentum may be initiated.

Third, this study has implications for other developmental courses in which students may need remediation. When a student success course is taken in combination with developmental reading or developmental writing, similar evidence of increased developmental course success may result though such study would need to be undertaken to confirm this assumption. This information could provide for strategic policy changes in community colleges that require any developmental student, despite the discipline, to take a prerequisite or corequisite student success course in order to enhance his or her developmental course completion.

Fourth, this investigation may further substantiate studies related to learning communities. In a theoretic learning community the same cohort of students take two or more of the same courses together. The courses are team taught. Each instructor attends the others' course(s) and provides learning support when they are not teaching their primary discipline. The instructors then weave assignments relating to the other discipline(s) into their own curriculum and classroom. Learning communities put an emphasis on learning how to learn and then sharing what is learned (Reigeluth, 1999). Courses taught in combination in learning communities have provided evidence of increased student course completion similar to this study (Reigeluth,1999). By pairing a student success course with a developmental mathematics course and utilizing the methodology of learning communities, it is possible that the benefits found in the achievement of each model may multiply.

Finally, there is evidence in this study to suggest that mathematics does not necessarily atrophy. Students entering the community college several years after high school graduation performed better in their developmental mathematics courses than students directly exiting high school. This study was not intended to explore this facet in depth, but it does bring into question the long-standing premise. The implications may be cause to investigate if there are points in time (two years/five years/ten years, etc.) when mathematics atrophy becomes more pronounced or if there are specific computational skills that are lost more readily over time.

Recommendations

Based upon the results of this study, several recommendations are suggested to implement systemic change and to expand upon research in this area. Despite strategies in delivery format and classroom pedagogies, developmental mathematics continues to be the area of greatest enrollment and consequent failure at any given community college in America (Bonham & Boylan, 2011). Developmental mathematics is a barrier to successful degree completion with many students failing to pass the course even on the third attempt (Charles A. Dana Center et al., 2012). This study provides an opportunity to improve upon this condition from a variety of approaches.

First, a delineation of developmental mathematics students would provide for an experience that is more personalized and tailored to their individual success. This study identified that there are differences between Level 1and Level 2 developmental mathematics when a student success course is taken. Students in the lower Level 1 course require deep remediation in mathematics. Per study results, these students complete their Level 1 course at higher rates when they take a student success course at the same time as Level 1 developmental mathematics. Therefore, the recommendation is that every student placing into Level 1 mathematics be required to take a corequisite student success course.

For students that place into Level 2 developmental mathematics, the findings suggest that they benefit when they take either a student success course with or within one year prior to developmental mathematics. Consequently, those in Level 2 developmental mathematics could be given the option to take a student success course with mathematics or postpone mathematics and take it within a year after the student success course is complete. Logistically, however, it could be problematic to have two separate tracking options offered within the developmental mathematics discipline. Additionally, learners with good intentions may fail to enroll in their mathematics course within a year of the student success course causing a necessity for the course to be repeated. Ultimately, institutions may choose to adopt a scenario in which all developmental mathematics students can benefit despite the level they place into. This would require articulation of policy to the lowest common denominator. In this scenario any student placing into developmental mathematics would also enroll in a mandatory student success corequisite course.

Second, because student success has been shown to have a positive correlation to another unrelated curriculum through this study, it is quite possible that a student success course could enhance many other disciplines as well. This may be especially noted with other developmental courses such as reading and writing. For this reason institutions may wish to consider making a student success course mandatory for all learners in community colleges. Ideally this course would be taken in students' first term in order to maximize the benefits of the transferable knowledge as they progress into other courses.

Third, it would be necessary to combine the above policies if a student success course is required of all learners or, conservatively, of all developmental learners. Students placing into developmental mathematics would also be required to take their mathematics course as a corequisite to the student success course in the first term. With additional investigation into developmental writing and reading, perhaps using techniques similar to those employed by this study, it might be found that this recommendation could be extended to those areas. That is, if a student places into developmental courses, he or she must take his or her developmental and student success courses in his or her first term(s).

Finally, the last recommendation for systemic change is based on the findings that suggest there is a positive association between developmental mathematics and the skills found in student success courses. With additional investigation into program level mathematics achievement after taking an SLS course, it may be possible to determine if there is benefit in revisiting the student success course curriculum during program level mathematics. If associations indicate a positive correlation, instructors might integrate the techniques of the student success course into their curriculum. One option would be to include a required lab component in order to review the student success material in the context of the course.

There are also recommendations that can be made for further research in this area. In this study, mathematics atrophy was not studied in detail. Findings suggest, however, that atrophy may not be as significant as what practitioners have come to believe. Students who had been out of high school for two years or more actually performed better in their developmental mathematics courses than their younger counterparts. This could be due to a plethora of variables. Future researchers are encouraged to explore this area more in depth to ascertain what is happening in the population regarding the diminishing of mathematics skills over time.

It would also be interesting to see further research in the area of Adelman's (2006) academic momentum theory. Adelman stated that students who complete 15 or more college credits within their first few terms attain their degrees at higher rates. This study suggests that when a student is in need of mathematics remediation, two of those very first courses should be student success and developmental mathematics. But what about the other nine credits? Is there an optimal selection of courses for students in their first term that would give them the greatest opportunity of achieving academic momentum? This would be groundbreaking to know and immeasurably valuable to community college practices.

Lastly, there are very little data available on the effect of student success courses (in the context of the whole course) on specific disciplines. It is quite possible that courses such as SLS could be effective corequisites to other developmental courses in reading and writing. Further, it is plausible that the course could bolster achievement in any challenging curriculum regardless of the discipline. Physics, anatomy and physiology, accounting, and engineering courses are vastly different; however, an increase in achievement could be possible if a success course were somehow integrated into the experience. Perhaps themed SLS courses in science, humanities, business and the like could produce similar results to those seen in this study.

Summary

This study set out to determine if student success courses were effective corequisites to developmental mathematics in community colleges. It was found that there is a significant positive correlation between corequisite student success courses and developmental mathematics. In order to arrive at this conclusion four hypotheses were tested throughout this study.

> H_o1: There is no statistically significant difference between Level 1 and Level 2 developmental mathematics course completion rates regardless of whether a student success course is taken as a corequisite.

The null hypothesis was rejected. A significant difference exists between Level 1 and Level 2 (combined) developmental mathematics course completion rates when a corequisite is taken compared to taking mathematics alone. In both MAT 0012 and MAT 0024 students exhibited a significant increase in course completion.

> H_o2: There is no statistically significant difference between Level 1 and Level 2 developmental mathematics course completion rates regardless of whether a student success course is taken within one year of taking the developmental mathematics course.

This null hypothesis was rejected. There is a statistically significant difference between Level 1 and Level 2 (combined) developmental mathematics course completion rates when a student success course is taken within one year prior of mathematics compared to those taking mathematics alone. The combined age groups indicated that student achievement increased when developmental mathematics was taken within one year after the student success course. The results of the individual age groups indicate that there is a possibility that the effect of increased achievement of mathematics after SLS does not affect the age group 21 or older, but the small sample size of this group is likely impacting the result.

H_o3: Regardless of whether a student success course is taken as a corequisite, there is no statistically significant difference between the age groups for students' developmental mathematics course (Level 1 and Level 2) completion rates.

The null hypothesis was rejected. A statistically significant difference exists between age groups when no SLS corequisite course is present in the sequence. When students took developmental mathematics alone (Level 1 and Level 2) the age group 21 or older had a significant higher achievement rate. When mathematics was taken during the same timeframe as SLS there was no significance in age groups found.

H_o4: Regardless whether a student success course is taken within one year, there is no statistically significant difference between the age groups of students' developmental mathematics course completion rates in Level 1 and Level 2.

The null hypothesis was rejected. A statistically significant difference exists between age groups when no student success course is taken within one year. When students took developmental mathematics alone (Level 1 and Level 2) the age group 21 or older had an achievement rate that was significantly higher. This discrepancy was not seen when a mathematics course was taken after an SLS course.

In Hypotheses 3 and 4, it is relevant to add further information to the findings. These two questions should also be considered in combination as to the extent age played when participants enrolled in a course sequence. It is interesting to note that when students took SLS as a corequisite or prerequisite, the completion rates of all ages in the study increased above those taking mathematics alone. When mathematics was taken alone, the age group 21 or older completed their developmental courses more frequently than those 20 or younger. When each age group was provided with an SLS course in their sequence, there was no significance found between the differences in their increased achievement.

The above hypotheses speak to the results of both MAT 0012 and MAT 0024 combined, allowing for the research to be generalized to developmental mathematics as a whole. In addition to these findings, detailed information regarding time from high school and individual course success was provided in this study. This investigation established that those in deep remediation are more positively impacted when a student success course is taken at the same time as their lower level developmental mathematics course. Taking student success within one year prior does not impact the achievement of any age group in deep remediation. Students in Level 2 mathematics remediation do better in the course when they take either a student success course during or within one year prior to their developmental mathematics course.

Based on this study, students who enter community college with a mathematics deficiency can benefit from a corequisite student success course. Students in deep remediation as well as those scoring just under program-level mathematics complete their developmental mathematics courses more often when they simultaneously enroll in a student success course. There is no evidence that indicates that those who have been out of high school for more than two years perform any differently when developmental mathematics and student success are taken together. Community colleges' noticeably low pass rates in developmental mathematics may be improved if policies were put in place that required a corequisite student success course for any student testing into developmental mathematics.

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