AN EXAMINATION OF A DEVELOPMENTAL MATHEMATICS SEQUENCE AT A COMMUNITY COLLEGE IN KANSAS

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Bethany Ann Chandler

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DEDICATION

This dissertation is dedicated to my family who made earning this degree possible. To my children, Ariane, Aidan, and Braxton, thank you so much for your patience and understanding when I needed to write or disappear for a while. My time with you is my favorite. It was never easy on my heart, but you never complained about me missing out on family time or being gone at night to write. I love you all and am very proud of each of you! Never give up on your dreams. To my husband Robby, it's finally over! Thank you for being my sounding board, for loving me through the stress, and for giving me the gift of time for more evenings and weekends than I can count. To my parents, Susan and Dennis Young, thank you for always making me feel empowered, loved, and optimistic about life. Your encouragement, support, and devotion to the people in our community led me to choose a career in teaching. Dad, your strong work ethic motivated me to be persistent and seek a career where I love what I do. A special thank you to my mom for all of the prayers, coke breaks, and making me laugh when I wanted to cry. To Pop, Harris Chandler, thank you for always stepping up to help with the kids (picking them up from school, feeding and caring for them) so I could work. I appreciate your pep talks when I wanted to give up. To Nana, Mary Chandler, your commitment to loving your family, and spending quality time with each of your grandkids was the most precious gift. You are deeply missed. Thank you for taking care of us and encouraging me to start this program. Finally, to my Nanny, Sarah Gustafson, who wanted to see me get this doctorate more than anyone else! I finally did it Nanny! I hope you are proud. Thank you all, for believing in me and supporting me, without you I would not have completed this journey.

ABSTRACT

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The purpose of this study was to investigate the relationship between the number of developmental mathematics courses students are required to take with respect to students' performance in college algebra, persistence rates, and degree completion at Butler Community College in Kansas. Also, examined was the extent to which age, gender, and ethnicity differentiated performance in college algebra, persistence rates, and degree completion for students taking developmental mathematics. A non-experimental, quantitative, retrospective, descriptive study was used. Participants were identified using archival data from Fall 2010 through Summer 2013. The criterion used to identify participants included first-time, full-time, degree seeking students, enrolled in at least one developmental mathematics course in the Fall 2010 semester.

A total of six research questions were used. Two research questions were constructed to determine if there was a statistically significant difference between students' entry developmental mathematics course and student performance in college algebra. The Welch was used to analyze the mean difference in college algebra grades and students' entry-level developmental mathematics course, and age, gender, and ethnicity. An additional four research question were constructed to assess the relationship between entry-level developmental mathematics course enrollment, and persistence, degree completion, and demographic characteristics. Chi-squared test of independence were used to examine the relationships between the variables for the third through sixth research questions.

The findings indicated students grades in college algebra could not be differentiated by students' placement in any particular level of developmental mathematics. Furthermore, students' grades in college algebra could not be differentiated by age, gender, or ethnicity based on students entry-level developmental mathematics course. Chi-squared results indicated there was not a statistically significant relationship between levels of developmental mathematics and student persistence for the first year. Additionally, on the whole, there were not statistically significant differences between persistence and age, gender, and ethnicity based on entry-level developmental mathematic course. Finally, there was no relationship between completion of a degree or certificate and entry-level developmental mathematics course or by age, gender, and ethnicity by entry-level developmental mathematics course in terms of completion

KEY WORDS: Developmental Mathematics, Graduation rates, Persistence rates, College Algebra, Community college, Age, Gender, Ethnicity

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CHAPTER 1

Introduction

Improving the success of developmental education has emerged as one of the biggest challenges facing many community colleges in their efforts to improve graduation rates. In order to meet former president Obama's challenge for the United States to lead the world in college completion by 2020 (The White House, n.d.), community colleges sought to find ways to increase success, retention, and graduation rates among developmental students. For many of these students, passing the mathematics requirement for graduation remains the biggest obstacle to degree attainment (Education Advisory Board, 2013). Through this study, an investigation of developmental mathematics students' path though the developmental sequence was investigated at a community college in Kansas.

Researchers have studied low graduation rates in community colleges, particularly the substantial barriers to degree completion that exist in developmental mathematics programs across the country (Bahr, 2010; Bailey, 2009; Hern, 2012). Certain college courses, particularly college algebra and the sequence of developmental mathematics courses, have surfaced as barriers to degree completion. A multistate study conducted by the Community College Research Center (CCRC) found that fewer than 10% of the students who placed three levels or more below college mathematics, ever go on to complete a college-level mathematics course (Hern, 2012). That study indicated 90% of students are lost in the course sequence before ever enrolling in a college-level mathematics course. A reason that the traditional developmental mathematics sequence has undermined the academic achievement of students in developmental courses has

been, in part, because of the numerous exit points (Edgecombe, 2011). Often, students see the completion of the developmental sequence as an insurmountable undertaking (McClenney & Dare, 2013). Although, remediation may delay time to degree completion for 2-year colleges, there is evidence that students who have completed remedial courses were more likely to graduate than similar students who did not take developmental courses (Attewell, Lavin, Domina, & Levey, 2006).

Statement of the Problem

During his administration, former President Obama pushed for an increase in graduation rates. Educational institutions across the country responded to the pressure from national, state, and local governments; they targeted developmental education as a cause of low graduation rates. With references such as the "Bermuda triangle of higher education" (Esch, 2009, para. 9), and "the bridge to nowhere" (Complete College America, 2012, p.2) developmental education unjustly has become synonymous with a dead end path. Nearly two thirds of all students entering community colleges will require at least one developmental course (Bailey, 2009), with the largest percentage of these students needing developmental mathematics. Similarly, Attewell et al. (2006) found that 30% of community college students pass their developmental mathematics courses; however, only 31% of these students complete their developmental education course sequence within 3 years.

The Education Advisory Board (2013) noted that a large proportion of students entering community college place into developmental mathematics and only a small fraction of those students ever progress to college-level mathematics, let alone attain a college credential. Many students who have placed into developmental mathematics

have been required to complete two or more courses before being enrolling in the college-level mathematics course needed for graduation (Bailey, Jeong, & Cho, 2009). Students placing into the lowest level may be required to take approximately 10 hours of developmental mathematics courses before being allowed to attempt their first college-level course (Bonham & Boylan, 2012). The number of developmental mathematics courses some students are required to take may impact their motivation, retention, persistence, and completion.

Purpose of the Study

The purpose of this study was to investigate the relationship between the number of developmental mathematics courses students are required to take with respect to degree completion, students' performance in college algebra, and persistence rates. Also, examined was to what extent individual characteristics differentiated graduation rates, persistence rates, and performance in college algebra for developmental mathematics students. The specific student characteristics analyzed included gender, age, and ethnicity. The participants of the study included first-time, full-time, degree seeking students at a community college in Kansas beginning Fall 2010 through Summer 2013. Through this study, an investigation of developmental mathematics students' paths at a Butler Community College (BCC) was conducted. Student's entry-level developmental mathematics course was one of the independent variables and was defined as the lowest level developmental mathematics course a student enrolled in. The dependent variables were degree completion (associates degree or certificate), persistence (enrollment the following semester), and course grade in college algebra (A, B, C, D or F). Age

(traditional, non-traditional), gender (men and women), and ethnicity (Asian, Black, White, and Hispanic) were the other independent variables.

Educational Significance

The findings from this study may add to the body of knowledge for BCC, in Kansas, and similar colleges. The results of this study can provide meaningful information to guide administrators and policy makers to improve students' success in developmental mathematics, college-level mathematics, and ultimately, improve students' chances for successful graduation. An analysis of the data gathered will identify areas of concern to help guide faculty, staff, and administrators in future steps to take to minimize obstacles in the current curriculum. Additionally, the results of this study might inform program directors to develop programs to improve student attrition rates for developmental mathematics students.

Furthermore, the findings from this study will add to the existing literature on developmental education. Although current literature exists regarding success in developmental mathematics, few studies have been conducted on the relationship between taking developmental mathematics courses and graduation rates (Wheeler & Bray, 2017, Bahr, 2013, Chen 2016). We have a limited understanding of the challenges students face outside the classroom. We do not have a good understanding of how students' decisions impact their academic pathways and how the pathways affect students' outcomes, thus we have a limited ability to influence these outcomes (Bahr, 2013). Knowing more about how the developmental mathematics course sequence affects students successful completion of a college credential will enable institutions to

craft better programs for students in mathematics to increase success, retention, and graduation rates.

Theoretical Framework

A number of theoretical models exists which explain the numerous variables that impact student decisions to remain in college or to stop or drop out. These models informed the theoretical framework for this study. Tinto (1975, 1987, 1988, 1993) is well known in higher education research because of his work related to retention, persistence, and student success. Tinto (1975) theorized that students enter college with a unique set of academic characteristics and skills stemming from their family background and upbringing (e.g., gender, ethnicity, academic aptitude, high school performance, family, social status) and goal commitments (e.g., degree expectations, importance of graduating from college) which have direct and indirect impacts on student performance and completion. Student departure from an institution takes place in a variety of forms and occurs for an array of individual and institutional reasons (Tinto, 1987). The variation of reasons for departure is as diverse as the institutional settings from which it arises (Tinto, 1987). Nevertheless, Tinto (1987) identified a number of major causes of student withdrawal from higher education including academic difficulty, inability to adjust to the academic and social life of college, lack of clearly defined goals, uncertainty of career goals over long periods of time, commitment to completion, and interaction with peers and faculty. According to Tinto (1993) the interaction between a student and his or her environment plays an integral role in determining the persistence of the student. Tinto's (1975) theory of institutional departure posited that academic and social integration into the college most directly influences the student's dedication to the institution and

persistence in that college. The greater the integration the greater the devotion to complete college.

A second theory used in this study was developed by Bean and Metzner (1985). The researchers expanded on Tinto's departure theory contending that Tinto (1975) focused too heavily on the social interaction of student's which contributed little to non-traditional student retention. Bean and Metzner (1985) identified non-traditional students as (a) more than 24 years of age, (b) part-time students, and (c) commuter students. More recently, Hagedorn and Kuzenetsova (2016) expanded the definition of nontraditional students to include "students who are employed, supporting their families, have a disability, and/or are veterans, in addition to students who are older or are people of color" (p. 49). It is well documented that a large population of non-traditional students attend community colleges. The National Center for Education Statistics (2015) reported 74% of all 2011-12 undergraduates had at least one of the following non-traditional student characteristics: being independent, having dependents, being sole care giver, not having earned a high school diploma, delaying post-secondary enrollment, having part-time enrollment status, and being employed full-time. Developing a profile for typical non-traditional students may be difficult because of the diverse characteristics used to describe this group. Also, it is important to understand the characteristics of these students in part because such a large percentage of students possess one or more of these characteristics. In addition, many of these characteristics of non-traditional students provide challenges for students that can affect their likelihood of persisting and attaining a degree. Bean and Metzner (1985) asserted non-traditional students are more affected by the external environmental factors than by social interactions.

Bean and Metzner's (1985) theory of non-traditional undergraduate student attrition was developed to take into account that non-traditional students rarely integrated socially with their institution and argued that that environmental variables had the greatest effect on non-traditional students decision to stay or leave post-secondary institutions. Bean and Metzner (1985) postulated that non-traditional students decisions to persist or drop out were based on (a) academic variables (e.g., study habits, academic advising, attendance issues, and course scheduling); (b) background variables (e.g., age, enrollment status, home life, high school performance, ethnicity, and gender; (c) psychological variables (e.g., goal commitment, stress, utility, and satisfaction); and (d) environmental variables (e.g., finances, employment workload, family responsibility, external support, and opportunity to transfer).

Bahr conducted a number of studies on the effectiveness of remediation. Bahr (2010) investigated the relationship between the depth and breadth of remediation and academic attainment. Depth referred to the degree of deficiency (number of levels they needed to complete) in a particular subject area such as mathematics or English and breadth referred to the number of different skill areas that students needed (Bahr, 2007). Bahr (2010) demonstrated that students who passed remedial courses in English and mathematics earned two-year credentials and transferred to 4-year colleges at rates comparable to those who entered college ready without the need for remediation. Bahr (2008), more specifically focused on the effectiveness of remedial mathematics. In his 2008 study of community college students, Bahr indicated that students who successfully completed their developmental mathematics sequence attained credentials at comparable

rates as students who achieved college credentials without the need for developmental mathematics courses.

Bahr's (2013) deconstructive approach constitutes a shift from the focus on simple outcomes to a focus on how students navigate through the various stages from entering college to a number of outcomes such as completion of a credential, transfer, or college-level mathematics competency. Rather than simply identifying if a student received a credential, Bahr's (2013) approach focused on gaining an "in-depth understanding of how students' progress or fail to progress through community colleges" (p.2). Developmental mathematics students, including non-traditional students, have more steps to climb that add time to their college journey and often have additional risk factors and challenges that affects their course-taking behavior. Although we know a great deal about the association between community college student characteristics and their outcomes, we know very little about the behavioral processes such as course-taking behaviors, recurring enrollment patterns, and the pathways that connect these characteristics to outcomes (Bahr, 2013). According to Bahr (2013),

> we have a painfully limited understanding of what community college students are doing between college entry and eventual exit, why they are doing it, and how the pathways that follow from these decisions bear on students' outcomes. As a result, our capacity to influence these outcomes also is sorely limited. (p. 138)

Bahr (2013) used a deconstructive approach that included two parts: a quantitative and qualitative approach. The quantitative approach required transcript analysis to explore the stages students go through to a given outcome of interest. The second part of

Bahr's (2013) approach was qualitative in orientation. This dissertation was influenced by Bahr's (2013) quantitative approach to transcript analysis.

Hagerdon and Kress (2008) also contended transcript analysis provides a wealth of data that has great potential for investigating community college success. The data collected by community colleges, such as the courses students take, the grades students earn, and degrees received provide a marker of student engagement, a map of the curriculum as traveled by the student and a time table of the journey to a degree (Hagerdon & Kress, 2008). This application of research to the community college in this study could provide a great deal of data to help illuminate students progression through the developmental mathematics sequence to college algebra and to college completion. Additionally, knowing where students are falling out or stopping out of the developmental mathematics pipeline and identifying links between students' characteristics and academic outcomes could help identify factors affecting developmental students' successful completion of college algebra and degree completion and provide insight that could lead to interventions to improve those outcomes.

Research Questions

1. To what extent do students' grades in college algebra differ based on students' required entry-level developmental mathematics course?
2. To what extent do students' grades in college algebra differ based on students' required entry-level developmental mathematics course and by demographics (age, gender, and ethnicity)?
3. What is the relationship between students' required entry-level developmental mathematics course and student persistence?

4. What is the relationship between students' required entry-level developmental mathematics course and student persistence by demographics (age, gender, and ethnicity)?
5. What is the relationship between students' required entry-level developmental mathematics course and degree completion?
6. What is the relationship between students' required entry-level developmental mathematics course and degree completion by demographics (age, gender, and ethnicity)?

Definition of terms

Completion. Completion for this study indicated a student had earned a degree or certificate.

Course grade: A course grade was assigned for all courses in which a student was regularly enrolled during the semester. Grades may be interpreted as follows A- excellent, B- good, C- average, D-poor, F-failing. All mathematics courses in this study require students to earn a C or better in order to be eligible to take the next course in the sequence. Additionally, all grade weights were consistent for all mathematics courses in the study.

Developmental Mathematics. Developmental mathematics courses differ by institution, however, the traditional mathematics sequence at most colleges includes a series of mathematics courses that start with basic arithmetic, prealgebra, fundamentals of algebra, and concluding with intermediate algebra. The developmental mathematics courses at BCC re as follows: MA010 Basic Arithmetic, MA020 Fractions Decimals and Percents, MA040 Basic Algebra Concepts, MA050 Prealgebra, MA060 Fundamentals of

Algebra, and MA125 Intermediate Algebra. Each of these courses must be passed with a C or better before a student can enroll in the college-level mathematics course. Stigler, Givvin, and Thompson (2010) found that developmental students were lacking in ability to perform these skills. For this study, developmental mathematics students are any student who enrolls in a mathematics course lower than college algebra.

Entry-Level Developmental Mathematics Course. The entry-level indicates the lowest-level course the students is required to enroll in first, based on a predetermined placement score. The developmental courses are sequential and require that students pass each course with a C or better before moving on to the next course. The entry-level course is the first course of the five courses offered that the students is placed in based on the placement test.

Graduation rate. The Kansas Board of Regents calculates graduation rates by tracking students who begin as first-time, full-time, degree seeking students who completed an associate's degree or certificate in 2-years (100%) and three years (150%) (Forsight 2020, 2018)

Persistence. Persistence for this study was defined as enrollment in the subsequent semester or having earned a credential.

Delimitations

In this study, the developmental mathematics sequence at a community college in Kansas was analyzed. The study included first-time, full-time students enrolled in fractions, decimals, and percents (MA020), basic algebra concepts (MA040), prealgebra (MA050), fundamentals of algebra (MA060) or intermediate algebra (MA125) from Fall 2010 through Summer 2013. The student's grade in each course, persistence from

semester to semester, and graduation rates were analyzed. The findings are not able to be generalizable to other institutions.

Limitations

Johnson and Christenson (2012) defined internal validity as "the ability to infer that a causal relationship exists between two variables" (p. 242). The limited scope of this study did not allow for examination of all of the variables that affect students' academic progress and graduation. For example, the study did not account for the varied teaching styles of the more than 70 instructors who teach developmental courses. Additionally, the instructors who teach these courses change each semester. Quality of instruction and teaching pedagogy may vary between instructors, which creates a threat to internal validity because the variations in instruction may have influenced course grades, persistence, and eventual graduation. Similarly, student motivation, use of resources, and events in their lives may contribute to students' academic achievement. Selection bias was another concern in this study and has been a common concern for developmental education studies (Bettinger & Long, 2005). For example, selection bias posed a threat to the internal validity of the study (Johnson & Christensen, 2012) because students selected their instructors, time of day for their classes, and method of delivery for their developmental mathematics courses. The study followed cohorts of students over a 3-year period. If students dropped out, it would be difficult to determine the reason why students left. The loss of people in a study is an internal validity threat referred to as attrition (Johnson & Christensen, 2012).

Threats to external validity jeopardize the certainty to state whether the study's results can be applicable to other groups. External validity is defined by Johnson and

Christensen (2012) as “the extent to which the result of study can be generalized to and across populations of persons, settings, times, outcomes, and treatment variation” (p. 256). Because this study used data from Fall 2010 through Summer 2013 from one community college, any conclusions drawn from the study are limited to BCC and may not be generalized to other time periods or institutions.

Organization of the Study

This study consists of five chapters. Chapter I includes the statement of the problem, purpose of this study, educational significance, theoretical framework, research questions, definition of terms, and limitation and delimitations of the study. Chapter II includes literature regarding the importance higher education, including the role of community colleges in completion and challenges encountered by community college students, the developmental mathematics sequence including controversial topics surrounding barriers to degree completion and the effectiveness of developmental mathematics. Chapter III contains the design and method used in this study as well as the institutional setting, selection criteria, data source, procedures, and data analysis. Chapter IV contains the results of the data. A summary of the results and conclusion are presented in Chapter V.

CHAPTER II

Review of Literature

The literature review includes studies on developmental mathematics and student performance in college algebra, as well as graduation and persistence rates in community colleges. In particular, the literature review focuses on the role of developmental mathematics and perceived barriers to degree completion that exist in developmental mathematics programs across the country. Certain college courses, predominantly college algebra, and the sequence of developmental mathematics courses and the courses that precede college algebra, have surfaced as barriers to degree completion. The majority of studies examined were quantitative and presented the negative impact that taking developmental education coursework has had on student persistence and graduation rates.

Importance of Higher Education

Traditionally, the United States has placed great value on the importance of higher education. A college degree holds promise for a better quality of life. An educated citizenry benefits individuals and society. Higher levels of education equate to higher incomes, less unemployment, and improved social mobility. According to White House (n.d.) officials, higher education is now the most direct pathway into the middle class with college graduates earning on average twice as much as that of workers in possession of only a high school diploma. A college education does not guarantee financial security or a good life, but for most people, postsecondary education improves the probability of a stable career with a positive income trajectory, and a college

education provides the tools needed to improve quality of life in several ways (Baum, Ma, & Paya, 2013).

Americans must attain some level of post-secondary education to be competitive in a global economy. Sepanik (2012) asserted, "It is now widely recognized that more young Americans than ever before will need postsecondary credentials in order to achieve economic self-sufficiency, which, in turn, is needed to maintain and strengthen our collective prosperity" (p. 1). Acknowledging that 75% of the fastest growing jobs require education beyond high school, former President Obama (2009) stated, "a good education is no longer just a pathway to opportunity-it is a pre-requisite" (para. 2).

Baum et al. (2013) indicated that college graduates with a bachelor's degree earn 65% more during their working life than high school graduates, and those with advanced degrees earn upwards of three times as much as high school graduates. In addition, individuals with an associate's degree or certificate have 27% and 13% higher median earnings, respectively, than high school graduates. Although the financial benefit of participation in higher education often has been emphasized as the primary benefit of postsecondary education, several other personal and social benefits can be realized. In addition to the monetary benefits for individuals and society, adults with higher levels of education tend to be more likely to (a) participate in organized volunteer work, (b) understand political issues, (c) vote, and (d) live happier and healthier lives (Baum et al., 2013). The societal benefits tend to be (a) an increased tax revenues and reduction in public expenditures; (b) a reduced health care cost; (c) an increased participation in educational activities with children; (d) an improved quality of civil society (Baum et al., 2013).

Despite the numerous benefits of earning a college credential, the United States has fallen behind in degree attainment internationally and is no longer leading the world in college completion (White House, n.d.). The nation is experiencing a college completion shortfall that is decreasing that nation's global competitiveness. Carnevale, Smith, and Strohl (2013) estimated that by 2020 the shortfall of credentialed American workers will exceed 5 million. This shortfall can be attributed in part to low college completion rates coupled with increased educational demand for new and replacement jobs. It is expected by 2020 that 65% of these jobs will require some level of education beyond high school (Carnevale et al., 2013). Either the demand for workers with postsecondary credentials will need to decelerate or the current graduation rates must increase approximately 10% a year to avoid the shortfall (Carnevale et al., 2010).

America's economic prosperity depends on an educated workforce. As Complete College America ([CCA], 2011) conveyed, "Unless we move with urgency, today's young people will be the first generation in American history to be less educated than their predecessors" (p. 2). The importance of a postsecondary degree was reflected in the former President Obama's college completion goal that was revealed in 2009, which sought to increase participation in higher education and to make America the world leader in percent of college graduates by 2020 (Obama, 2009). In response to the former President Obama's goal to increase college completion rates, many states, colleges, and organizations have responded to the call for action and the national spotlight has turned to community colleges.

Community colleges' role in completion. Community colleges have been instrumental in expanding access to higher education, and community college student

success was central to the goals of the Obama administration. According to the American Association of Community Colleges (AACC; 2016), 45% of all college students attend community college. In his remarks at Macomb Community College in Warren, Michigan, former President Obama (2009) emphasized the value of community colleges in educating Americans, stating,:

> We know that in the coming years, jobs requiring at least an associate degree are projected to grow twice as fast as jobs requiring no college experience. We will not fill those jobs-or even keep those jobs here in America-without the training offered by community colleges. (para.15)

Former President Obama (2009) further emphasized the critical role of community colleges with the introduction of The American Graduation Initiative aimed at reforming and strengthening community colleges, to increase certificate and degree attainment by an additional five million by the year 2020. Additionally, the AACC, together with five orgaizations, responded to the challenge to increase the percentage of adults with college credentials by authoring the completion agenda, which seeks to produce 50% more graduates with 2-year degrees or certificates by 2020 (McPhail, 2011).

Challenges for community college students. Historically, community colleges have prided themselves in being open-access institutions that welcome all that are willing to learn; however, the increased attention on completion has shifted focus from access for all to student success and equity of outcomes (AACC, 2015). Across the nation, completion and retention rates at community colleges have been historically low (McPhail, 2011). According to Scriver and Coghlan (2011), of students nationwide who enter community colleges to attain associate degrees or earn certificates, only one third of

the students are prepared for entry-level, credit-bearing college classes. The open door policy allows access to community colleges for all students, but attaining success in college is far more difficult. Attewell et al. (2011) indicated "68% of degree students who began at two-year colleges had not earned a degree 6 years later" (p.536). To improve degree and certificate completion rates, the AACC made a public commitment to increase time persistence and graduation rates by 50% by the year 2020 (McPhail, 2011).

Although community colleges play a critical role in increasing completion rates, a number of challenges exist within community colleges. Community colleges are comprised of a diverse group of students with varied motivations and goals for attending college. In addition, community colleges have larger percentages of nontraditional, lower-socioeconomic and more ethnically-diverse students compared to 4-year colleges and universities. Often, community colleges enroll a student population that face challenges outside of college that contribute negatively to their educational attainment. Some of the challenges include (a) raising children, (b) working, (c) being single parents, (d) delaying college enrollment several years after graduating from high school, and (e) attending school part-time.

According to Bailey et al. (2009), students who attend part-time are less likely to graduate. Complete College America (2011) expressed part-time student's graduation results as "tragic" (p, 8). In their study, only 7.8% of part-time students received an associate's degree compared to 18.8% of full-time students who earned the same degree. In their report Shapiro et al. (2015) also indicated full-time students completed their postsecondary education (54.6%) at a higher rate than students enrolled part-time

(18.3%) or those who had mixed enrollment (35.1%), which included students who enrolled full-time for some of the terms during the study period and enrolled part-time during other terms of the semester. Furthermore, Shapiro (2015) reported that completion rates for 2-year public institutions completing their degree or certificate at their starting intuition was 41.8% for full-time students. Shapiro et al. (2015) further expressed the important role that 2-year institutions play in achieving the national completion agenda goals stating that "the highest percentage of exclusively full-time students who completed at four year intuitions had already attained a credential from a 2-year institution" (p. 30).

It should be noted that full-time attendance has not been the best path to degree completion for many returning adult students (Fein, 2015). A national study conducted on non-first-time college students, showed that adult community college students who previously had pursued a degree and were returning were more likely to complete an associate's degree if they mixed part-time and full-time enrollment (Fein, 2015). Seventy-five percent of today's students are tasked with managing some combination of family, work, and school while commuting to class (CCA, 2011). Mixing part-time and full-time enrollment allows students the flexibility to balance work, family, personal and financial commitments with academics.

The AACC (2016) reported the majority of community college students are the first in their families to go to college, and lack academic role models and educational support from their families. The AACC (2016) stated that the majority of community college students arrive at the institution with a substantial need for academic skill

development, and for help in other areas of their lives—child care, financial aid, and counseling.

Bahr (2012) asserted,

> In part because of the flexibility offered to students, community colleges make the impossible possible. Students who would otherwise be excluded from postsecondary education for any number of reasons (e.g. obligations to work or family, financial limitations, inadequate preparation for college) find opportunity in community college…In reality, community college is the primary door through which nontraditional, underrepresented, low income, and first generation students enter postsecondary education. (p. 4)

Colleges must respond to the array of academic, financial, and emotional needs to retain students while improving students' opportunities for success and completion.

Challenges for developmental mathematics students. There are numerous reasons students lack motivation to take developmental courses, which include but is not limited to (a) the cost for non-credit classes, (b) the extra time needed to compete developmental course work, and (c) the fear of failure. For many students, passing the mathematics requirement for graduation remains the biggest barrier to degree attainment. Being placed in developmental mathematics classes brings with it additional challenges. A number of non-academic factors must be considered to help students develop self-confidence and self-efficacy and to take the locus of control for their own learning (Zientek, Fong, & Phelps, 2019; Zientek, Yetkiner, Fong, & Griffin, 2013). Hall and Ponton (2005) stated, "for developmental mathematic students, academic self-concepts, attitudes toward success in mathematics, mathematics anxiety and self-efficacy, and locus

of control are all variables that affect students' goals, performance and attainments in mathematics" (p. 26).

Furthermore, Fowler and Bowlan (2010) asserted, "Nonacademic (affective) and personal factors related to students success become increasing important for students with weak academic skills" (p. 2). Students placed in developmental mathematics courses often experience (a) mathematics anxiety, (b) negative attitudes, (c) poor study skills, and (d) lack of responsibility (Spradling & Ackerman, 2010). In fact, empirical evidence indicates that developmental mathematics students experience higher levels of mathematics anxiety than the adult population (Zientek, Yetkiner, & Thompson, 2010). Non-academic factors are receiving heightened attention across disciplines. The Education Advisory Board claimed "traits like productive persistence, grit, curiosity, optimism, and self-control play a tremendous role in students' success" (Community College Forum, 2013, p. 102). According to Boylan (2009), "The weaker a student's cognitive skill, the more important other affective factors are in student success" (p. 15). Simply addressing the mathematical needs of students enrolled in developmental mathematics is not sufficient.

Foresight 2020

Traditionally, upward mobility depends on a person's access to higher education and Kansas is no exception in the quest to provide quality postsecondary education for its citizens. Foresight 2020 is a 10-year strategic agenda for the Kansas public higher education system that includes three overarching long-range goals: (a) increase higher education attainment for Kansans, (b) improve alignment of the state's higher education system with the economic needs of the state, and (c) ensure state university excellence

(Kansas Board of Regents [KBOR], 2013). Empirical data supports Kansas' need for available postsecondary education; " as provided by a Georgetown University study, 64% of Kansas jobs will require some level of postsecondary attainment by 2018" (KBOR, 2013, p. 1).

According to the KBOR (2013), the growth in the number of Kansas high school graduates over the next ten years is expected to be minimal. With the limited number of high school graduates projected, policy makers at the state level, educational administrators at the state level and local levels, and professional educators at all levels in the K-12 arena must be proactive in their effort to recruit, retain, and graduate more students in order to increase postsecondary education attainment in Kansas. Two specific objectives identified in Foresight 2020 were aimed at the first goal of increasing educational attainment among Kansas citizens. These objectives are to increase the number of Kansas adults who have a certificate, an associate degree, or a bachelor's degree to 60% and achieve a 10% increase in graduation and retention rates. Completing these objectives will require accelerating the progress the Kansas higher education system has been making over the past six years (KBOR, 2013).

A number of reasons why increasing participation in higher education are important to Kansas policy makers and citizens exist. Areas of Kansas with higher levels of post-secondary achievement have a higher median income level, tend to be more civic minded, and pass on their knowledge and ambitions to their children, which in turn provides a path to multigenerational success (KBOR, 2013). In addition, obtaining a postsecondary credential has become increasingly important for economic success at both the personal and state level. Rose (2013) suggested that college graduates earn more

money over a lifetime, have lower unemployment rates, are healthier, have higher marriage rates, and are engaged in their communities. Although many benefits can be gleaned from attaining a postsecondary credential, any time spent in postsecondary education is valuable and relevant as postsecondary education provides essential skills necessary for success in work and in life.

The KBOR (2013) asserted, "In order for Kansas to experience the full benefits of having a highly educated citizenry, it is imperative that students who enter the higher education system leave with a postsecondary credential" (p. 5). Retention and graduation rates are commonly used benchmarks to measure institutional and student progress. The KBOR (2013) determines retention rates by tracking undergraduates who are enrolled in the first and second fall terms at the same institution. For community college and technical schools in Kansas, graduation rates are determined by the number of students who graduate within three years from initial enrollment.

Not surprisingly, if more students are retained, a greater number of students will be more likely to graduate. However, retention and degree completion do not fully capture the full postsecondary experience, particularly for 2-year institutions, where students often attend to refresh job skills or complete a certain number of credits before transferring to a 4-year college or university. The KBOR (2013) expressed, "The public higher education system is the largest producer of individuals with the skills and credentials necessary to fuel the Kansas economy and meet projected workforce demands" (p. 7) and "by the end of this decade (i.e., 2020), over 60% of Kansas jobs will require some p" (p. 9). Economic prosperity relies on an educated workforce; therefore, policy makers and higher education administrators must be cognizant of and responsive

to specific needs in the workforce. Although obtaining a postsecondary credential is essential for workforce production and personal growth, any postsecondary experience is valuable and relevant.

Perceived Barriers to Degree Completion

Developmental mathematics. Developmental education and the controversy surrounding it may seem new in the higher education realm; however, meeting the needs of underprepared students has been an essential part of higher education for decades (Arendale, 2011). Although a number of national and state initiatives have been undertaken in public education to increase college readiness, many students enter community college underprepared for college-level instruction. These students are placed in developmental education, with the majority of community college students testing into developmental mathematics (Bailey, Jeong, & Cho, 2010; Education Advisory Board, 2013). Due to the high enrollment and reported low success rates, developmental mathematics has been of particular concern (Melguizo, Kosiewiez, Prather, & Bos, 2014). According to Boylan and Bonham (2007), "Developmental education refers to a broad range of courses and services organized and delivered in an effort to retain students and ensure the successful completion of their postsecondary goals" (p. 2). Developmental education aims to improve the academic skills, personal growth, and knowledge of underprepared college students, typically in the areas of mathematics, reading, and writing.

Bailey et al. (2010) suggested developmental education is a fairly simple concept; students who are underprepared for college-level work are provided instruction that prepares them for success in college-level courses; however, they acknowledge the

practice of developmental education is “complex and confusing” (p. 1). Further, Bailey et al. (2010) suggested that the developmental education process from the student’s perspective “may appear as a bewildering set of unanticipated obstacles” (p. 1).

The fundamental tenet of developmental education is equity of opportunity; thus, students who successfully complete developmental courses should share academic outcomes that are comparable to the academic outcomes of students who are deemed college ready and do not require remediation (Bahr, 2008). Bettinger, Boatman, and Long (2013) suggested developmental courses are the “gateway to college-level courses” (p. 96). Students who do not place into college-level mathematics are referred to developmental courses designed to prepare them for success in college-level mathematics (Bailey et al., 2010).

Nationwide, approximately 70% of students have been required to take at least one developmental mathematics course; however, only 40% of those students complete a credit-bearing mathematics course (Ngo & Kosiewicz, 2017). Most developmental mathematics programs include a series of three or more courses that must be successfully completed before students can enroll in a college-level mathematics course. Students placing into the lowest level may be required to take approximately 10 hours of developmental mathematics courses before being allowed to attempt the college-level course (Bonham & Boylan, 2012).

The long sequence of courses negatively influences students’ motivation and retention, persistence, and completion rates. The Education Advisory Board (2013) indicated over one half of the students entering community college place into developmental mathematics and only a small portion of these students persist to college-

level mathematics, let alone attain a college credential. Often, students see the completion of the developmental sequence as an insurmountable undertaking (McClenney & Dare, 2013). Hall and Ponton (2005) suggested that many of the students who place in developmental education feel a stigma that is damaging to self-perceptions. Unfortunately, the courses that were designed to provide educational opportunity have become synonymous with barriers to degree attainment (Boylan & Bonham 2012). McCabe (2000) asserted "helping underprepared students may be the most important service that community colleges can render to our country" (p. 44).

Reducing the amount of students assigned to developmental mathematics courses and identifying factors that contribute to or hinder students' success in these courses are topics of concern for many educators across the county. In an effort to assist in understanding how the developmental education experience might be improved, Zientek, Schneider, and Onwuegbuzie (2014) investigated the perceptions developmental mathematics faculty have regarding why students are placed into developmental mathematics courses and what factors hinder students success in these courses. The researchers distributed an online survey to developmental mathematics faculty at six community colleges and one university across four states. The faculty were asked to describe the factors they believe impact students need to be placed in developmental education and what factors hinder the success of students. The data was categorized into themes. The results indicated a time delay from a prior mathematics course and a lack of basic mathematics skills as the two most common explanations for why faculty believed students are placed into developmental mathematics courses. Academic behaviors and

work habits, dispositional factors, and situational factors surfaced as the most common factors that affected student success (Zientek et al., 2014).

Zientek et al. (2014) suggested increasing communication to high school students regarding the effect of time delay between graduation and college enrollment. Colleges and secondary schools should collaborate more to help students be successful, offering self-remediation to students during the enrollment process, implementing interventions designed to improve self-regulation, offering the placement test and tutorials outside of normal college hours, and providing professional development to faculty regarding the impact that dispositional and academic behaviors have on student performance. As both entities work together, students required to take developmental courses will have more self-efficacy and persist to graduation.

Placement/Assessment. Although numerous factors affect the academic achievement of community college students, inconsistent standards of college readiness and inaccurate course placement create other barriers to improved student outcomes for developmental students. Research-based placement policies and procedures are a critical component in students' successful transition from high school to college. Fulton, Gianneschi, Blanco, and DeMaria (2015) indicated that current placement procedures are often detrimental to student's success. Although "it is harmful to assume that every entering college student is ready for college-level courses " (Saxon & Morante, 2014, p. 30), many students are unaware that they are not ready for college-level courses until they take college placement tests and are assigned to developmental courses. In addition, many students have been incorrectly placed in developmental courses while others are placed in college-level courses when they are not ready. Scott-Clayton, Crosta, and,

Belfield (2014) asserted that approximately one-third of students testing into English and one quarter of test takers in mathematics are severely miss-assigned. Students who are college ready and incorrectly assigned to developmental courses may or may not gain any educational benefit, but they incur additional cost and time that may discourage or delay degree completion (Scott-Clayton et al., 2014).

Inconsistency in placement procedures creates confusion for students choosing colleges and for high schools in terms of how to prepare students to be college-ready (Jaggars, 2011). Generally, there is a lack of consistency about what constitutes college readiness (Bailey & Cho, 2010). Many of the traditional placement tests and policies do not accurately determine students' college readiness. Students who are referred to developmental courses contend with a variety of different problems and skill deficiencies. Traditional placement tests do not differentiate diverse groups of students who need different types of services (Bailey & Cho, 2010). However, researchers reported several states are moving away from using traditional assessment and looking at a broader range of measures to determine which courses are most appropriate for students (Fulton et al., 2015, Bailey & Cho, 2010). Improved assessments could lead to more tailored developmental programs that reduce the amount of time students devote to developmental courses.

Critics of commonly used placement procedures assert that current assessment and placement practices inaccurately place students and lack predictive validity. Saxon and Morante (2014) discussed criticism of assessment and placement processes often used in community college to place students in developmental courses and provided recommendations for improvement. Further, Saxon and Morante (2014) acknowledged

that there are a number of challenges with current assessment and placement processes, including (a) lack of support for students prior to taking the assessment, (b) improper use of test scores, (c) failure to include multiple measures in student assessment, (d) inadequate advising systems, (e) failure to mandate assessment and placement, and (f) allowing students to avoid the assessment process. Moreover, Saxon and Morante (2014) asserted that placement assessment may not predict student success. Variables, such as attitude, dedication, maturity, health, and attendance, are factors in student success, which are not typically assessed by common placement tests. Attendance in particular has been identified as important to student success in developmental mathematics courses (Albert, Zientek, & Manage, 2018; Zientek et al., 2013).

Saxon and Morante (2014) contended placement tests can only explain a small amount of variance for student's grades in developmental courses and should not be used as predictors of success. Saxon and Morante (2014) concurring with Gerlaugh, Thompson, Boylan, and Davis (2007) further suggested placement assessment should be a comprehensive coordinated process. Saxon and Morante (2014) offered a number of recommendations for improving the placement assessment process, including (a) improving alignment between college and high school, (b) requiring mandatory assessment, (c) advising and placement for all students, (d) using multiple variables such as high school GPA and non-cognitive factors when assessing students, (e) including diagnostic assessment instruments, (f) using cut score ranges instead of a single cut off score, (g) developing student attribute profiles, and (h) systematically evaluating the assessment process.

Belfield and Costa (2011) examined the use of placement tests and high school transcripts in predicting post-secondary course grades and performance. According to Belfield and Costa (2011), "…high school GPA is by far a better predictor of success than the placement tests" (p. 22) Furthermore, Belfield and Costa claimed "HS GPA is the only information needed from a student's high school transcript to predict performance in college" (p. 18). Hughes and Scott-Clayton (2011) questioned the efficacy of placement assessments used to place students in developmental education and suggested that the placement protocol typically used in community colleges could be improved. A larger number of institutions rely on one placement instrument to assess students for placement. Although each assessment instrument includes published test reliability and validity information, Hughes and Scott-Clayton (2011) questioned whether the assessment instruments have predictive validity. These researchers suggested that the placement assessments typically used in community colleges are better at predicting which students will earn a B or higher rather than determining who is at risk of failing. With the aforementioned test information in mind, Hughes and Scott-Clayton (2011) proposed that using multiple measures of assessment would lead to better student placement. They contended that if the purpose of placement testing is to increase low-performing student success then using of a single cognitive assessment instrument is ineffective. Recognizing students come to higher education with more than academic issues, Hughes and Scott-Clayton (2011) suggested using assessment instruments that measured behavioral and non-cognitive attributes, in conjunction with a cognitive placement test, would provide a more holistic view of student's abilities. Additionally, Hughes and Scott-Clayton (2011) and Gerlaugh et al. (2007) suggested a targeted

intervention approach to placement, where students are matched with comprehensive student support services, could lead to better placement.

Traditional developmental mathematics sequence. According to Bailey and Cho (2010) approximately 60% of students starting college are referred to at least one developmental course and suggested many are referred to multiple levels, rather than an individual course. Bailey et al. (2009) found that while the majority of enrollments in developmental courses do result in course completion, those who actually complete the required sequence in three years is somewhere between 33% and 46% of students. As the push to graduate more students continues to gain momentum, researchers have been shifting their focus from implementation of success strategies in individual courses to a focus on increasing completion of developmental course sequences. Addressing the needs of development students may be the most important and challenging problem facing community colleges (Bailey & Cho, 2010). Wiley Periodicals (2012) reported that "according to Achieving the Dream, a national non-profit dedicated to increasing completion rates at community colleges, less than one-third of all community college students referred to developmental course work have completed their sequence of required courses within three years" (p. 4). In Kansas, 17% of students at 2-year colleges complete the developmental sequence and associated college-level courses within two years (Kansas Board of Regents, 2012).

The CCRC conducted a study of students requiring more than two levels of developmental mathematics across multiple states which indicated "more than 90% of these students" are lost in the course sequence and ultimately fail to enroll in the college-level mathematics course (Hern, 2012, p. 60). The traditional sequence undermines the

academic achievement of students in developmental courses in part because of the numerous exit points (Edgercomb, 2011). Traditionally, developmental mathematics courses are structured in a 16-week, semester-long format in which students must successfully complete one course in order to move on to the next course in the sequence. In some cases, students have been referred to multiple levels of developmental courses (Bailey & Cho, 2010). The traditional sequence for the community college in the present study consists of five levels of developmental mathematics courses beginning with fractions and decimals and ending with Intermediate Algebra. Once students successfully complete Intermediate Algebra, they are considered college ready and allowed to take college algebra, which is the college-level mathematics course required for graduation from this institution.

This long sequence of courses designed to prepare students to succeed in college level courses can pose as a barrier to degree completion (Boatman, 2014). For students needing remediation, time is a major barrier to achieving success in a college-level course or obtaining a degree. Without successful completion of college algebra, graduation is not possible. Bailey (2009) found that only 16% of students placed in the lowest developmental mathematics course completed the developmental mathematics sequence in three years. Bahr (2012) examined the remedial mathematics and remedial writing sequence for an explanation of why students are lost in the developmental sequence. The data included in the study came from the Chancellor's Office of the California Community College (CCC) database system and included "first-time college students in California's 105 semester-based community colleges who began in the Fall of 2001, Fall of 2002, or Fall 2003, who reported having a valid social security number" (Bahr, 2012,

p. 665). According to Bahr (2012), duration of enrollment is not the only explanation for the struggles of remedial students. Bahr (2012) examined "nonspecific attrition, skill-specific attrition, and course-specific attrition" (p. 665). The results of the study indicated more than 50% of those students eligible to attempt the next course in the developmental sequence actually completed the course (Bahr, 2012). Furthermore, Bahr (2012) reported positive associations between passing the first mathematics course in the sequence the first time and the successful completion of mathematics courses in the sequence. According to Bailey (2009), current studies suggest that minimizing the amount of time students spend in their developmental course sequence increases the student's chances for degree completion.

Fong, Melguizo, Prather, and Bos (2013) looked at how students move through the developmental mathematics course sequence and noted that "the traditional way of calculating progression rates…is to divide the number of students passing the course at the end of the sequence by the total number of students initially placed at a specific lower level" (Fong et al., 2013, pp. 1-2). Using a new method, "developmental mathematics progress is based on the number of students who are actually attempting and passing each subsequent course" (Fong et al., 2013, p. 3). With this method, they found the passing rates for students at each level are similar, indicating developmental mathematics courses are providing students with the skills and knowledge that lead to successful completion of subsequent courses.

Time to degree completion. Time continues to be a barrier to degree completion and success in college-level courses. The recent attention on developmental education as a barrier to degree attainment has fueled initiatives aimed at accelerated models of

remediation intended to reduce the amount of time students spend in developmental courses and ultimately increase graduation rates. There are different models of acceleration that indicate promise for improving success in developmental education, including co-requisite courses, compressed courses, modularization, and pathways. The alternative models attempt to help students move through the sequence more quickly and target student's individual academic needs. A common characteristic among accelerated courses is the opportunity for students to complete their developmental course work in one or two semesters versus the traditional sequence, that can take students up to two years to complete. Among the most popular forms of acceleration are compressed courses, paired courses, and curricular redesign (Edgercombe, 2011).

Compressed courses shorten the length of individual courses from a traditional 16-week format to a shorter length of time, allowing two courses to be completed in one semester. There are a variety of ways to compress a semester long course into a shorter time frame. Any course that is offered for the same amount of course credit, but in a shortened time frame such 6-week courses, rather than a semester long course would be considered a compressed course. The content remains the same, just the time frame to learn the content is condensed to fewer weeks. Sheldon and Durdella (2009) used archival data from" a large, suburban community college in southern California" (p. 39) to examine the relationship between course duration and student success in developmental courses. The compressed courses in the study were available in six and eight week formats. The authors revealed that students who participated in compressed-format courses were more likely to succeed than students taking the traditional courses. Sheldon and Durdella (2009) reported "course length was associated with statistically and

practically significant differences in course success in developmental courses, and the differences were consistently observed across age, gender, and ethnicity" (p. 52). Although Sheldon and Durdells (2009) suggested that developmental students can effectively learn and understand course content in a shorter amount of time when the content is provided in a more concentrated, compressed format, the authors did not examine the effectiveness of providing a sequence of developmental courses in a compressed format.

Paired courses, sometimes called co-requisite courses, link developmental courses to college-level courses, which allow students to complete both the developmental course and the college-level course in the same semester (Jaggars, Edgecombe, & Stacey, 2014). The Accelerated Learning Program (ALP) at the Community College of Baltimore has experienced tremendous success with this model. The ALP is a co-requisite model that provides students who place in an upper-level developmental writing course the opportunity to enroll in the college-level English course concurrently with the developmental course. The same instructor teaches the developmental-level course in addition to the college-level course. The developmental writing course is a cohort of 10 students who meet immediately after the college-level English course. The Community College of Denver offers a variety of pairings in English, reading, and mathematics as part of their FastStart program, which combines multiple levels of courses coupled with additional student support (Fulton, Gianneschi, Blanco, & DeMaria, 2014).

Curricular redesign decreases the number of courses in the sequence by eliminating repeated content. Modularization has been one of the most common approaches of curricular redesign, and it has emerged as an effective strategy to address

this issue (Ariovich &Walker, 2014; Edgercombe, 2011). Modularization moves students more efficiently through the sequence by separating the traditional curriculum into discrete units of study, but does not mean simply dividing the course content in modules and continuing to teach in a traditional classroom setting with teacher-led activities. This strategy individualizes the student experience by allowing students to complete only the modules they need (Wyrick, 2009). According to Fulton et al. (2014), "Modular approaches are popular among educators interested in tailoring developmental instruction for large numbers of students with wide-ranging academic deficiencies" (p. 40). The most common formats are (a) teacher led, one credit, 4-week courses or (b) computer-mediated variable-credit shell courses. However, the delivery of modules varies considerably across institutions and some overlap exists between the emporium model and modularization.

North Carolina and Virginia have separated developmental mathematics content into one-credit hour modules (Bickerstaff et al., 2014). Metropolitan Community College offers the modular format for Elementary Algebra through College Algebra. Students use a software program and work at their own pace while following an individualized study plan (Fulton et al., 2014). Administrators and faculty at Cleveland State Community College have successfully implemented an emporium model where they divided the content of the three developmental mathematics courses into 32 mini-modules. Students are required to attend class for one hour each week and work in the mathematics lab for a minimum of two hours each week. In order to keep students on task, one module is due each week (Wyrick, 2009). Tennessee SMART Math consists of 12 instructional modules. Data from this model indicated students completed the

SMART Math sequences at higher rates than students who took the traditional developmental mathematics courses (Bassett & Frost, 2010).

In a traditional developmental mathematics sequences, which vary by school, students are placed into one or more developmental mathematics courses based on a placement test. Students are expected to complete each course, one semester at time, until completing the entire sequence regardless of students' needs. For many colleges, this traditional approach takes a minimum of three semesters. The modularized approach often affords students the opportunity to complete the developmental mathematics sequence in one semester. Enrollment is continual and the need for students to repeat content is eliminated. By tailoring the curriculum to students' academic needs and career goals, the modular approach reduces time in the developmental sequence and increases completion rates (Community College Forum, 2013).

The role of the students and instructor changes in the modular approach to learning; the focus shifts from instructor lectures to student-centered learning. Students are actively engaged in the learning process and cannot bypass content they do not understand. The focus shifts from a one-size-fits-all mindset to a mastery-learning approach where each student is required to master the content before moving on to the next task. Modularized instructional strategies divide course material into smaller instructional units to allow students to focus on the particular set of skills in which they are deficient. Many modularized courses integrate computer-based instruction (Epper & Baker, 2009) and mastery learning.

Although the initiatives reviewed in the literature provide a framework for course restructuring and show promise, longitudinal data showing the effectiveness of

acceleration at increasing success and graduation rates is lacking. The acceleration model has been gaining popularity; however, further research is needed to address problems with implementation and to determine the effect that acceleration has on developmental students' completion of gateway courses and graduation rates.

College algebra completion. The aim of developmental education is to prepare students to be successful in that first college-level course. Attaining a college degree is dependent upon successful completion of college-level mathematics courses, which often have been referred to as "gateway" courses. However, Bailey et al. (2010) instead referred to first-level college courses as "gatekeeper" courses. College algebra is the gateway course for the majority of community colleges in Kansas and serves as the college-level course requirement for most associate degrees in Kansas. According to Bailey et al. (2010), the results of a CCRC study of 250,000 community college students indicated only 20% of students referred to developmental mathematics and 37% of students referred to developmental reading enroll in and pass the relevant entry-level or gateway college course. Although these numbers sound bleak, many students who complete developmental courses do not enroll in the gateway courses (Bailey et al., 2010) According to Bailey et al. (2010), "failure to enroll is a greater barrier than course failure or withdrawal" (p. 3). In a study conducted by the CCRC on progression through developmental courses and summarized in Bailey et al. (2010), 42% of students who were referred to developmental mathematics, but never enrolled, had not earned a college credential in three years after their first term.

A CCRC study of a statewide community college system reported one third of developmental mathematics students enrolled in gateway courses and nearly three fourths

of college-ready students enrolled in gateway mathematics (Jenkins, Jaggars, & Roksa, 2009). The pass rates among developmental and college-ready students who enrolled in a gateway mathematics course were similar, hovering around 75%, regardless of what level of remedial course they had taken or whether they skipped their recommended developmental courses. However, due to low overall gateway enrollment rates (36% for mathematics), just over a quarter of the students in the study passed a gateway algebra course (Jenkins et al., 2009). Calcagno, Crosta, Bailey, and Jenkins (2006) determined that "passing college algebra was predicted to have a positive impact on graduation possibilities for all students" (p. 4).

Credit hours. Martorell and McFarlin (2010) reported that remediation reduces the number of academic credit hours earned by 2.4 in students' first year for 2-year institutions and 1.5 for 4-year institutions. Expanding their analysis to a 6-year period resulted in the reduction in academic credits ranging from 3 to 6 credits for 2-year institutions. In addition, Martorell and McFarlin (2010) reported statistically insignificant effects between remediation and college completion, labor market earnings, and the prospect of transferring to a 4-year college. Contrary to Martorell and McFarlin's (2010) findings, Bettinger and Long (2005) suggested that developmental education provided diminutive benefit to marginal students. Furthermore, Bettinger and Long (2005) reported that community college students placed in developmental mathematics courses were 15% more likely to transfer to a 4-year college and completed 10 more credit hours than students with similar backgrounds and level of academic preparedness. In addition, Calcagno and Long (2008) sampled more than 100,000 first-time Florida community college students and concluded that remedial mathematics and reading courses improve

the persistence of student enrollment from fall to fall and increased the overall number of credits earned over a 6-year period. However, they noted that remediation did not increase the number of college-level credits earned or credential completion.

Bahr (2012) conducted a study of community college developmental mathematics students' course taking behavior. He specifically focused on what he referred to as the "after-math period" (p. 196) which he refers to as the period of time that students are still enrolled in the community college but have dropped out of the developmental mathematics course sequence. Bahr (2012) reported students who stopped participating in developmental mathematics courses earned fewer course credits in the after math period regardless of the point in which they dropped out of the developmental mathematics sequence. However, students who did not achieve college-level mathematics competency prior to dropping out reduced their course credit load more than students who achieved college-level mathematics competency. Bahr (2012) stated,

> Remedial math students who do not achieve college-level math competency tend to have a significantly lower mean course credit load after exiting the remedial mathematics sequence than they had prior to exiting the sequence, slowing their academic progress during the critical ''make-or-break'' after-math period. (p.196)

Student Performance

Although there are numerous barriers affecting community college students' success, numerous ways to predict, define, and evaluate student's success are available and beneficial. Many developmental education studies have focused on retention and degree completion; however, a number of other factors can be used to evaluate the effects and benefits of developmental education programs. The importance of grades,

persistence, gateway course completion, and credit hours earned during the community college experience are a few factors that should not be overlooked. Additionally, analyzing and understanding how student's characteristics affect grades, persistence, and degree completion is essential.

Students from traditionally disenfranchised groups have been more likely to require developmental classes. In a study on remedial course taking, Chen (2016) indicated 78% of Black students and 73% of Hispanic students were enrolled in developmental courses at public 2-year institutions compared to 64% of White students. Additionally, Chen (2016) reported that 75% of students in the lowest income group enrolled in developmental courses compared to 59% of students in the highest income group who enrolled in developmental courses. Furthermore, proportionally more females than males enrolled in developmental courses at 2-year institutions (Chen 2016).

Grades. Grades in previous classes, both in high school and college, have been demonstrated to predict success in college-level courses. Adelman (2006) asserted that the high school curriculum was a strong predictor of college readiness. For example, students who successfully complete a rigorous high school curriculum are more likely to be college ready and succeed in college-level courses. However, Benken, Ramirez, Li, and Westnendorf (2015) suggested that educators should reexamine the meaning behind being college ready. Also, Benken et al. (2015) questioned whether earning a grade of "C" truly indicated that students could be successful at the next level, and they suggested that high school coursework may not be rigorous enough to prepare students for analogous college courses.

In a study for the Nevada public colleges and universities, Fong, Huang, and Goel (2008) reported that students who did well in less rigorous courses in high school, such as algebra and trigonometry, were less likely to require remediation, as compared with students who performed poorly in more advanced mathematics courses, such as Pre-Calculus. For example, students who completed an algebra or trigonometry course with an overall grade of "A" were less likely to require a remedial mathematics course in college (15% compared to 24%) compared to students who completed a more advanced course, such as Pre-Calculus, with an overall grade of "C."

Acosta (2016) conducted a study that examined the student performance of community college students who took a college-level mathematics courses after completing their developmental mathematics sequence. She examined the impact of three risk factors: (a) developmental mathematics course format (i.e., online or on campus), (b) students grades preceding enrollment in college-level mathematics, and (c) "time-lapse since completing high school" (p. 2). Although modality and time-lapse were not reported to be predictors of completing college-level mathematics with a C or better, student GPA was determined to be an important predictor of successful completion of a college-level mathematics course. Using retroactive data and logistic regression analysis, the results of Acosta's (2016) study indicated GPA was a statistically significant predictor of college-level mathematics success. Acosta (2016) reported that "for every 1-point increase in college GPA, students were 3.64 times more likely to complete college-level mathematics with a C or better" (p. 6). Acosta (2016), hypothesized student's use of resources available to them at the college, may have been a contributing factor to the GPA being a good indicator of future success.

Demographic Characteristics and grades. Academic stereotypes such as the preconceived notion that men are better at mathematics than women (Good et al., 2012) have existed for decades. The alleged gender gap between mathematic achievement between boys and girls remains one of the most controversial developmental questions for elementary school psychologists (Schwery, Hulac & Schweinle, 2016). Stereotypes can affect people's beliefs. Some research suggests the belief that men are better than women in mathematics may impact test performance and career choice for women (Schwery et al., 2016). Additionally, in a study conducted by Lu et al., (2015) stereotype threat caused enough anxiety in women to contribute to lower academic success. When mathematics achievement was measured by mathematics course grades, the gender gap appears to be closing or even reversed (Schwerin et al. 2016). According to Robinson and Lubienski (2011) girls were outperforming boys in elementary and middle school classrooms. This trend continued in high school and even into college. Griffen et al. (2011) reported female experienced more success overall in college courses. Similarly, Bremer, et al. (2013) indicated women in developmental education courses obtained higher GPAs **(**Bremer et al., 2013). Ndum, Allen, Way, and Casillas (2017) examined to what extent psychosocial factors played a role in explaining the gender gaps in English Composition and College Algebra. The researchers reported females earned an average grade of 2.6 in college algebra whereas men obtained an average grade of 2.2 and indicated that the odds of succeeding in college algebra were 72% higher for females than for males. Regardless of those encouraging statistics, more females than males have been enrolled in developmental mathematics courses (Chen, 2016).

Wolfle (2012) conducted an ex post facto quantitative study that followed students who enrolled in a Virginia Community College over a five-year period. Wolfle (2012) examined the effect of age and ethnicity combined with developmental mathematics on the academic success of students in their first college-level mathematics courses. According to Wolfle (2012), non-traditional age students were more likely than traditional age students to succeed in their first college-level mathematics course.

Black and Hispanic students outnumber other ethnicities in developmental education courses (Crips & Delgado, 2014, Ganga, Mazzariello, & Edgecombe, 2018) and have lower rates of successful remediation in mathematics (Bahr, 2010). Additionally, Bremer et al., (2013) reported White Non-Hispanic developmental students were more likely to graduate and obtain higher GPAs. Furthermore, Wolfe (2012) reported White students were 1.29 times more likely to succeed compared to their non-White peers. Bahr (2010) contended the racial gap in successful remediation is "exacerbated" by the disproportionate representation of Black and Hispanic students who perform poorly in their first mathematics class, suggesting that poor performance in first mathematics class deters students from the pursuing college-level mathematics achievement (p. 232). Bahr (2010) asserted there is a strong relationship between race, performance in the first mathematics course and the likelihood of remediating successfully. In his study, Bahr (2010) reported 43% of students who earned an A in their first mathematics course remediated successfully, whereas only 11.8% of students who earned an F in their first mathematics course and 11.2% of students who withdrew from their first mathematics course remediated successfully. Furthermore, White students were more likely to receive an A in their first mathematics course compared to

Black students and Black students were more likely to receive a grade of F or withdraw compared to White students, contributing to the strong racial differences in successful remediation (Bahr, 2010).

Persistence. One of the necessary components for underprepared students to successfully complete college algebra is their dedication and determination to complete the developmental mathematics sequence leading to college algebra. In developmental education literature, many predictors of persistence are considered, including: (a) passing developmental courses, (b) participating in student support services programs, and (c) receiving financial aid. Another important predictor is the number of courses in which students enroll and drop in their first full semester (Fike & Fike, 2008). Additionally, non-cognitive factors, such as: (a) student self-perception, (b) confidence, (c) attitudes, (d) beliefs, and (e) the ability to control anxiety levels, are essential factors for student persistence and success (Benken et al., 2015). The success of developmental mathematics courses often has been discussed by comparing the outcomes of college-level mathematics courses of students who required at least one developmental mathematics course compared to students who did not require developmental mathematics (Wolfle, 2012).

Chen and Simone (2016) indicated students who had completed developmental mathematics classes were more likely to enroll and earn credit in a college-level mathematics classes (71% and 69% respectively) than students who did not take developmental mathematics classes (53% took college-level and 48% earned credit). Further, in an effort to flush out the contradictory research on the effect of basic skills mathematics in community colleges, Melguizo, Bos, and Practher (2011) reviewed the

literature regarding how developmental mathematics impacts the "educational outcomes and persistence of community college students" (p.173). Melguizo et al. (2011) focused on descriptive, quasi-experimental, and experimental studies, discussing the (a) discrepancies, (b) highlights, and (c) limitations of summative quantitative evaluation techniques commonly used in research on the effectiveness of developmental mathematics. As a result of their critical literature review, Melguizo et al. (2011) contended "descriptive studies present conflicting evidence that makes it really hard to understand the impact of basic skills mathematics on student's educational outcomes" (p.177). The primary limitation of descriptive studies, according to Melguizo et al. (2011), is biased results. Using correlation studies, researchers typically compared the outcomes of students who participated in developmental mathematics to students who did not participate in developmental mathematics (Melguizo et al., 2011).

Although the quasi-experimental studies identified by Melguizo et al. (2011) "attempted to control for the preexisting differences between students who take basic skills courses and those who do not" (p.175), evidence of the effects of remediation was still limited. Few studies have explicitly controlled for selection bias in terms of unobservable characteristics, such as motivation and aptitude (Melguizo et al., 2011).

The final quantitative research design identified by Melguizo et al. (2011) was randomized trials or experimental design. In this design, the researcher controls for preexisting differences between students. The random assignment of students in experimental research studies makes it possible to make causal inferences; however, it is not possible to evaluate developmental mathematics with randomized assignment because students typically have been placed into developmental mathematics. It is not

possible to randomly assign students to various levels of developmental mathematics and make all observable and non-observable characteristics equal between control and non-control groups.

Melguizo et al. (2011) indicated that a regression discontinuity design "is the closest non-experimental research design to a random assignment experiment of which a portion of students would be assigned to one level of mathematics and a portion would be assigned to the next higher level" (p. 176). According to Melguizo et al. (2011), focusing on the students who score close to the cut off scores using a regression discontinuity design mimics true random assignment. Also, Melguizo et al. (2011) reported the difference in ability of those taking the test will vary little within the sample; therefore, the assignment to different levels of mathematics would be determined by testing error rather than difference in student's ability. Melguizo et al. (2011) identified regression discontinuity as the most promising research design to evaluate the California Basic Skills Initiative (CBSI) because this statistical method enables researchers to make causal inferences. Additionally, Melguizo et al. (2011) suggested regression discontinuity could be used as an evaluation tool for CBSI to determine if the institutional support and resources provided translated to students' success. Using regression discontinuity statewide could allow researcher to identify schools that are doing a good job of providing developmental education or more specifically identify populations of students that are facing greater challenges (Melguizo et al., 2011). According to Melguizo et al. (2011), the regression discontinuity design is an effective and useful method for institution, district, or statewide evaluation due to the large longitudinal samples and intuitive techniques.

Using the Achieving the Dream: Community Colleges Count, a multiyear, national initiative, Bailey et al. (2009) analyzed student placement and progression in developmental mathematics and reading. The study included 57 colleges with 256,672 first-time, credential-seeking students who enrolled between Fall 2003 to Fall 2004. Bailey et al. (2009) followed these students for three years and organized the data into two categories based on referral into developmental education and developmental enrollment without referral. In addition, three levels of remediation in both mathematics and reading were available: (a) Level I, which is one level below the gatekeeper course, (b) Level II, which is two levels below the gatekeeper course, and (c) Level III, which is three or more levels below the gatekeeper course. Of those students referred to developmental education, the completion rate in mathematics Level I, Level II, and Level III were 45%, 32%, and 17%, respectively, with an overall completion rate of 33%. For reading, completion rates were 50%, 42%, and 29%, respectively, with an overall rate of 46%. The researchers further examined passing rates for developmental students who completed the sequences and then enrolled in the gatekeeper courses. The results for mathematics and reading respectively were Level I – 78% and 75%, Level II – 81% and 75%, and Level III – 78% and 75%. The data clearly indicated that students were passing the gatekeeper courses if they persisted long enough to enroll.

Bettinger and Long (2005) used a longitudinal data set between 1998 and 2003 from the Ohio Board of Regents and conducted a regression analysis. Their study looked at approximately 13,000 first-time freshmen enrolling in public 2-year colleges in Ohio. From the analysis, Bettinger and Long (2005) determined that nearly 67% of all Ohio community college students enrolling in remedial courses persisted through their first

semester. The researchers examined enrollment data from applications and transcripts and "compared students with similar backgrounds and levels of academic preparedness at colleges with different remedial placement policies" (p. 23). Based on the findings, Bettinger and Long (2005), determined that "once differences in backgrounds are accounted for, remedial education no longer affects students negatively" (p.24). Bettinger and Long (2005) corroborated the findings of Fong et al. (2013) indicating the issue of persistence is not with the developmental mathematics sequence alone, but also includes "financial obstacles and family obligations" (p. 3). These studies indicated developmental education is working and benefits students who are furthering their education and achieving their academic goals.

Boylan and Bonham (1992) conducted a study to gather information on "the effects of developmental programs on cumulative GPA, long-term retention, [and] subsequent performance in regular college classes" (p. 1). Originally, 150 institutions were selected for the study using a circular systematic random sampling process. By the time this report was written, 108 institutions had provided enough data to be included in the study. Boylan and Bonham (1992) examined admissions information, financial aid data, and transcripts from a random sample of students at both 4-year and 2-year institutions. From the 4-year institutions, data were collected from the fall of 1984 through the spring of 1990. From the 2-year institutions, data were collected from the fall of 1986 through the spring of 1990. The researchers were able to determine the persistence rates for 5,166 students from transcripts, and they divided the institutions into the following categories: (a) 2-year community colleges, (b) 2-year technical colleges, (c) 4-year public institutions, (d) 4-year private institutions, and (e) research universities.

They combined persistence and graduation rates together. The graduation and persistence results for each of these institutions were 24.0%, 33.7%, 28.4%, 40.2%, and 48.3%, respectively. Graduation and persistence rates are two long-term outcomes that should be included when evaluating a developmental education program. Systematic program evaluation is a best practice in developmental education, and according to Boylan (2002), "research has shown that developmental programs undertaking regular and systematic evaluation are more successful" (p. 39).

Gerlaugh et al. (2007) conducted a follow-up to the study "between 1990 and 1996 [by] the National Center for Developmental Education" (p.1). Once again, the researchers used a systematic circular sampling at 2-year institutions and invited 45 institutions to participate in the study. Twenty-nine of these institutions, or 64.4%, were able to provide enough data to participate in the study. Institutions were asked to provide data on enrollment from Fall 2001 through Summer 2003 and also were given a survey of questions for clarification of the information they were providing. Gerlaugh et al. (2007) used specific data to measure effectiveness, including (a) completion, (b) pass rates, and (c) grades in first college credit course. For reading, 83% of students were retained, 76% of students passed the developmental course, and 69% of students passed the first college credit course. For writing, 83% of students were retained, 73% of students passed the developmental course, and 64% of students passed the first college credit course. Finally, for mathematics, 80% of students were retained, 68% of students passed the developmental course, and 58% of students passed the first college credit course. At many institutions, program evaluation has been implemented since the original study. In fact, Gerlaugh et al. (2007) reported that 62% of all developmental programs in the

follow-up versus 14% of all developmental programs in the original study evaluated their programs regularly; indicating institutions are examining the research and reading the literature to implement changes based on credible, reliable information.

In 2009, Harr completed a quantitative study of all first-time freshmen at Morehead State University entering school in the fall of 2002. Harr (2009) investigated the differences in the graduation and persistence rates for each of the cohort groups by location and between those students requiring developmental education and not requiring developmental education. The sample size was 1,546 students, of which 55% were required to take at least one developmental course. Two cohort groups were examined: (a) students requiring developmental mathematics and English courses and (b) students not requiring developmental education courses. The results of this study indicated performance in developmental education courses were predictive of performance in gatekeeper courses. In addition, a correlation between student persistence and performance in developmental coursework was evident. Bailey et al. (2010) highlighted persistence and the goal of completing a gateway course, stating "failure to enroll is a greater barrier than course failure or withdrawal" (p. 3).

Demographic Characteristics and Persistence. Although most studies indicated female students persisted more than males (Bailey et al., 2009, Davidson & Petrosko 2015), Conger and Long (2010) offered some possible explanations for this discrepancy. Bailey et al. (2009) indicated gender had a strong effect on persistence throughout the entire developmental mathematics sequence. Female students were 1.53 to 1.56 more likely to persist through the developmental mathematics course sequence than were their male counterparts. Similarly, in their study of developmental mathematics students

enrolled in Kentucky's public 2-year community and technical college system. Davidson and Petrosko (2015), reported, "…being female increased persistence…" (p. 169). Conger and Long (2010) suggested males' beginning college with lower grades from high school and their tendency to choose harder classes could partially explain why women have higher persistence rates.

. The research on the effects of age on persistence contained inconsistent messages. Wolfe (2012) reported that no statistically significant difference existed between traditional and non-traditional age students in fall-to fall persistence. In contrast, Bailey et al. (2009) indicated older student had lower odds of persisting through the developmental sequence. Davidson and Petrosko (2015) determined that age was statistically significant for dependent students. In their study, Davidson and Petrosko (2015) used logistic regression to examine the relationship between persistence and demographics, academics, work and family factors, and reported "In all three analyses younger students are more likely to persist" (p. 170).

Mixed results also plague the question of the influence of ethnicity on indicating non-White students experience similar levels of success and persistence as do White students. According to Bailey et al. (2009), Black students' odds of persisting through the developmental mathematics sequence were 0.67-0.91 times the odds of White students. The odds were lower when Black students were referred to developmental mathematics two or more levels below college-level mathematics.

Degree Completion. A cursory look at graduation rates at 2-year colleges reveal students who require developmental education have lower graduation rates than those who do not need developmental courses. The comparison of schools over time indicates

there is a gap in graduation rates during a 3-year time span for students placed into developmental education. Fewer than one quarter of students who enroll in developmental education at the community college level complete a degree or certificate within eight years of enrollment (Bailey & Cho, 2010). Complete College America (2012) reported most students who enrolled in remedial courses never graduated. Only 10% graduated from a 2-year college within three years, and 35% graduated from a 4-year college within six years. The Kansas Board of Regents (2014) indicated "Kansas students were somewhat more successful with 18% completing at 2-year colleges within three years and 36% graduating from 4-year colleges within six years"(p.4).

Although taking remediation may delay time to degree completion for 2-year colleges, there is evidence that students who complete remedial courses were more likely to graduate than similar students who did not take developmental courses (Attewell et al., 2006). Bahr (2008) conducted a study of 85,894 freshmen enrolled in 107 community colleges to test the efficacy of postsecondary developmental mathematics programs. In his study, Bahr (2008) asserted that students who successfully remediate exhibit credential completion and transfer at rates similar to students who are successful in college-level mathematics who do not require developmental education. Similarly, Chen and Simone (2016) used data from the 2004/09 Beginning Postsecondary Students Longitudinal Study and the 2009 Postsecondary Education Transcript Study to analyze postsecondary outcomes for developmental students and reported that students who completed developmental mathematics courses at 2-year institutions tended to earn more college-level mathematics credits than student who did not take developmental courses. Boylan and Saxon (2012) suggested "Developmental Education is perhaps the first line of

defense to ensure these students benefit from higher education" (p 5). It seems important for students to begin their programs of study early in their careers because students who enter a program of study during their first year of college are more likely to earn a college degree than students who are forced to wait until their second year to begin taking college-level courses (Jenkins & Cho, 2012).

Bailey et al. (2009) indicated completion rates for developmental students are negatively associated with the number of developmental courses that they are referred to. In the fourth annual report on national college completion rates, Shapiro, et al. (2015) reported the 6-year outcomes for student who started at 2-year public institutions. The researchers reported 38.2% of students who started in higher education at a 2-year institution had completed a degree or certificated within in six years. Of those who had completed a degree at 2-year institutions 26.2% completed at the institution where they began, 3.2% completed at a different 2-year institution, and 9.0 % had completed at a 4-year institution. Overall, 15.1% of students who began at 2-year intuitions completed a 4-year degree during the 6-year period the study was conducted. Of those who completed at a 4-year institution, 6.1% had earned a degree or certificate from a 2-year institution and 9% had transferred without earning a degree. Wheeler and Bray (2017) examined the relationship between gender, race, developmental status, and graduation rates and reported developmental courses positively impacted students' likelihood of graduating. Further stating "Developmental courses are often viewed negatively, but this study shows that they can play an incredibly important role in helping students graduate, improving their odds of graduating substantially" (p. 14)

Demographic Characteristics and Degree Completion. Women slightly outperform men in completion rates. In their nationwide study Shapiro et al (2015) indicated 41.5 % of women and 35.7 % of men who started at 2-year public institutions had completed a degree or certificate within six years. Similarly, Conger and Long (2010) reported men completed college at lower rates than women.

While younger students complete their education at a higher rate, older students may be at less of a disadvantage if they are able to attend full time. Shapiro et al. (2015) data showed full-time traditional age students, 20 or younger, who attended 2-year institutions had the highest completion rate compared to full-time, non-traditional students. Community college students who attended exclusively full-time had a completion rate of 49.5 % compared to a 25.6% completion rate for part-time community college students.

Certain ethnic groups have fared better than others in higher education and the intersection of gender and ethnicity seems to play a role. For example, Wheeler and Bray (2017) stated "Odds of graduating were higher for female, non-White students, and students placed in developmental mathematics…" (p. 14). Ganga et al. (2018) considered specific ethnic groups stating "….Black and Hispanic students who take developmental courses graduate at lower rates than White and Asian students who take developmental courses…" (p. 3)

Summary

Research on the effectiveness of developmental mathematics is mixed at best. There is inconsistent data in favor of and against developmental education. The national spotlight on developmental education and the complexity of factors that contribute to

underprepared students success has created new challenges for community colleges. The debate over developmental education revolves around a few factors including effective research methods, the role of developmental education, and the effectiveness of developmental education. In the academic arena some researchers value developmental education while other researchers claim developmental education is a barrier (Atwell et al., 2006; Bahr 2008; Bailey et al. 2010; CCA 2012).

However, researchers, whether for or against developmental education, reported that a growing number of students are entering college underprepared for college level work. Many future jobs will require some post-secondary education. Community colleges are in a position to provide a starting point for many students who do not fit the mold of financially capable, academically prepared, and recently graduated students who live in the dorms and can devote time exclusively to school. Most community colleges students however do not enroll prepared to take college-level courses. Therefore, community college should provide effective developmental education programs to help students complete their gateway courses and have the same opportunities for college success as their non-developmental peers. Accurate placement into the correct courses is both vital and difficult to accomplish without considering several measurable and affective variables.

One of the struggles educators face is how to address the multitude of challenges that developmental students face and help provide programs and support that enables them to persist through to degree or certificate completion. Many students who complete one developmental course do not enroll in the next course. Some approaches to minimize

time students spend in developmental courses include concurrent classes, accelerated courses, and modules.

Many factors (e.g., gender, age, and ethnicity) affect success in developmental mathematics classes and later in college algebra. Although the persistent stereotype that men are better at mathematics than women is no longer true (Robinson & Lubeiennski, 2011; Schwaertal, 2016), this belief can still affect women's self-efficacy and life choices. (Good et al., 2012; Schwaertal, 2016). Most studies indicated women persisted more than males and slightly outperformed men in completion rates.

Age has been reported to be a factor in students' success in their first college-level mathematics course, with non-traditional age students having a greater likelihood of success (Wolfle, 2012). Black and Hispanic students are more likely to be enrolled in developmental classes and Black students are more likely to fail their first mathematics course than their White counterparts (Bahr, 2010). Identifying factors that contribute to students' success and persistence in the developmental mathematics course sequence and college algebra is important for meeting the challenge of improved persistence and graduation rates. More research is needed to understand what works in developmental mathematics course sequences and how individual student characteristics contribute to student persistence and overall success. This study will add to the research on developmental mathematics programs at community colleges.

CHAPTER I

Method

Introduction

Improving the success of developmental education has emerged as one of the biggest challenges facing many community colleges in their efforts to improve graduation rates. In order to meet former president Obama's challenge for the United States to lead the world in college completion by 2020 (The White House, n.d), community colleges must find ways to increase success, retention, and graduation rates among developmental students. For many of these students, passing the mathematics requirement for graduation remains the biggest barrier to degree attainment.

Researchers (Bahr; 2010; Bailey, 2009; Hern, 2012) have studied graduation rates in community colleges, particularly the obstacles to degree completion that exist in developmental mathematics programs across the country. Certain college courses, predominately college algebra and the sequence of developmental mathematics courses, have surfaced as barriers to degree completion. Often students see the completion of the multicourse developmental mathematics sequence as an insurmountable undertaking (McClenney & Dare, 2013). According to Edgecomb (2011), the traditional developmental course sequence undermines the academic achievement of students in developmental courses in part because of the numerous exit points. Similarly, a multistate study conducted by the Community College Research Center found that fewer than 10% of the students who placed three levels or more below college mathematics ever go on to complete a college-level mathematics course which indicated 90% of students stop out or drop out of the course sequence before ever enrolling in the college-

level mathematics course (Hern, 2012). Although taking remediation may delay time to degree completion for 2-year colleges, there is evidence that students who complete remedial courses were more likely to graduate than similar students who did not take developmental courses (Attewell, Lavin, Domina, & Levey, 2006). The purpose of this study was to investigate the relationship between the number of developmental mathematics courses students are required to take with respect to degree completion, student performance in college algebra, and persistence rates.

Research Questions

1. To what extent do students' grade in college algebra differ based on students' required entry-level developmental mathematics course?
2. To what extent do students' grades in college algebra differ based on students' required entry-level developmental mathematics course and by demographics (age, gender, and ethnicity)?
3. What is the relationship between students' required entry-level developmental mathematics course and student persistence?
4. What is the relationship between students' required entry-level developmental mathematics course and student persistence by demographics (age, gender, and ethnicity)?
5. What is the relationship between students' required entry-level developmental mathematics course and degree completion?
6. What is the relationship between students' required entry-level developmental mathematics course and degree completion by demographics (age, gender, and ethnicity)?

Research Design

This quantitative, non-experimental study examined the relationship between the number of developmental mathematics courses students are required to take with respect to student grades in college algebra, persistence, and degree completion. In addition, the relationship was further disaggregated by age, gender, and ethnicity. The researcher looked backwards in time to collect actual data from the past, therefore, by design, this was a retrospective, descriptive study (Johnson & Christensen, 2012). According to Johnson and Christensen (2012), the focus of descriptive research is on "describing the variables that exist in in a given situation and sometimes on the relationships that exist among these variables" (p. 366). Non-experimental research aligns to this study because there was no manipulation of the independent variable or random assignment to groups (Johnson & Christensen, 2012). The researcher studied what had already occurred in an educational environment and how the variables are related but did not attempt to provide evidence of causality (Johnson & Christensen, 2012).

Institutional Setting

The participants in this study were selected using archival data from the Institutional Research office at BCC, which is the second largest community college in Kansas and the 6th largest educational institution in the state. Butler Community College is a multi-campus institution serving approximately 13,000 students each year across seven sites including online. There are two main campuses. The original campus was established in El Dorado in 1927 and is home to the residence halls. The Andover campus is located just outside of a large metropolitan area and is mostly a commuter campus. A large number of international and non-traditional students attend the Andover campus,

whereas the El Dorado campus serves more traditional students, including a number of students involved in extracurricular activities. Students choose BCC for a variety of reasons ranging from academics to athletics. Butler Community College offers 101 degree and certificate programs including Culinary Arts, Nursing, Business Administration, Computer Information Technology, and Early college academies. In addition to a wide range of academic programs, BCC has a nationally ranked Livestock Judging team, a well-known vocal music program, and stellar athletic programs. The athletic programs include soccer, cross county, track and field, baseball, basketball, volleyball, sprit squad, football, and softball. Indeed, BCC has one of the best National Junior College Athletic Association (NJCAA) football programs in the nation as well as back-to-back NJCAA National Championship softball teams.

The population at BCC is 65 % White followed by 11% Hispanic, 9% Black, 5% Asian, and 1% American Indian or Alaskan Native (KBOR, 2017). The majority of students attend part-time. According to KBOR (2017) students who are enrolled in at least 24-credit hours in an academic year are considered full time. In 2016, 10,176 out of 13,055 students attended part time (KBOR, 2017). Nearly 40% of the students were between the ages of 20 and 24, followed by 28% between the ages of 25 and 44, and approximately 23% of students were between the ages of 18-19. Additionally, 5% of the population were under 18 and a little more than 4% were between the ages of 45 and 64.

Selection Criteria

The participants in this study were selected using purposive sampling from archival data from the Institutional Research Office at Butler Community College. The participants were selected from 20th day enrollment data for Fall 2010. The 20th day

was chosen because in the state of Kansas every post-secondary institution is required to submit specific enrollment data to KBOR during the fall and spring terms; this is the official enrollment data reporting date state-wide in Kansas. Utilizing a purposive sampling technique a researcher specifies the traits of a population of interest and then selects individuals with those characteristics to be included in the study (Johnson & Christensen, 2012). The first selection criterion identified first-time, full-time, degree-seeking students. The second selection criterion further reduced the identified participant pool to those enrolled in at least one developmental mathematics course. Once participants were identified using the criteria, the participants were categorized by the lowest level developmental mathematics course required. These participants were chosen in order to determine a possible relationship between persistence and the level of developmental mathematics required and degree completion and the level of developmental mathematics required.

Data Source

Archival data from the institutional research department at BCC included a 20th day enrollment data file, nine semesters of end-of-term grade data files, and two completion data files. The 20th day enrollment file from Fall 2010 included the following demographic information: age, gender, and ethnicity, as well as, student type, and student status. The demographic variables are self-reported by the students on the application for admission form. Advisors input student's educational goal and major. Age was represented as a decimal rounded to 8 places. The researcher restructured the ages into categories making it an ordinally scaled variable. The age categories were chosen based on KBOR reporting data. The categories for age were: 0 = less than 18, 1 =

18-19, 2 = 20-24, 3= 25-44, 4 = 45-64 and 5 = 65 or greater. Gender was a dichotomous variable where the males were coded as 0 and females were coded as 1. Ethnicity, student type, student status, and educational goal were all nominal. Ethnicity was coded as follows: Other = 0, Black = 1, White = 2, Hispanic = 3. Students identified as high school were individuals who had not yet graduated from high school. New students were new to BCC, continuing students had taken at least one course at BCC in a previous semester, and transfer students had transferred to BCC from another college. Student type was coded as Continuing = 0, High School =1, New = 2, Transfer = 3. Student status was identified as full-time, half-time or less than half-time. Full-time status was defined as enrollment in 12 or more credit hours per semester. The end of term files contained course enrollments and grade data from Fall 2010 through Summer 2013. Final grade in college algebra was coded as: A = 4, B = 3, C = 2, D =1, and F = 0. The completion files identified degree and certificate recipients annually.

In sum, the data used in this study describe 738 first-time, full-time, degree-seeking students taking at least one developmental mathematics course beginning Fall 2010. The students ranged in age from 17 to 50 years old (M = 19.94, SD = 3.57) with a 95% confidence interval of 19.68 to 20.20. There were 345 males and 393 females. The ethnic distribution for the study was as follows: 63.14% White (n = 466), 18.56% Black (n = 137), 9.76% Hispanic (n = 72), 8.54%, Other (n = 63). Among the four levels of developmental mathematics courses included in the study, 47.70% of the participants (n = 352) began in MA120 or MA125, the highest level developmental mathematics course, followed by 26.29% (n = 194) in MA060, 19.92% (n = 147) in MA050, and 6.10% (n = 45) in MA020, the lowest level developmental mathematics course included in the study.

Procedures

Prior to collecting archival data, the researcher obtained permission from the Associate Vice-President of Research and Institutional Effectiveness at BCC and approval from the Institutional Review Board of Sam Houston State University. Because archival data were used there was no more than minimal risk or harm to the subjects and written consent was not required. The archived data were obtained through a secure shared drive located at BCC. The researcher had access to these data as part of her normal duties as an employee of the college.

After acquiring the approval needed to carry out the research, archival data for the participants were obtained from a secure shared drive at BCC from Fall 2010 through Summer 2013. These data included the Fall 2010 20th day enrollment report, end of term data for Fall 2010, Spring 2011, Summer 2011, Fall 2011, Spring 2012, Summer 2012, Fall 2012, Spring 2013, Summer 2013, and Completion Reports from 2012 and 2013. Data were coded and imported into SPSS.

Data Analysis

The variables included in this study were levels of developmental mathematics required, grade in college algebra, persistence, degree completion, age, gender, and ethnicity. To address the first research question focused on mean differences in course grade based on entry-level developmental mathematics course enrollment a one-way ANOVA was planned. One-way ANOVA tests are used to determine if there are any statistically significant differences between the means of two or more independent groups. Specifically, a one-way ANOVA compares two or more independent groups on the dependent variable. The independent categorical variable in this study was the entry-

level developmental mathematics course, the dependent variable was course grade in college algebra. Prior to conducting the analysis, the researcher checked for violations to the following assumptions: (a) approximately normal distribution and (b) homogeneity of variance. To test for normality, the skewness and kurtosis test statistic was used. The Levene's test was used to evaluate equality of variance. In cases of violation of the assumption of normality, the non-parametric Kruskal-Wallis test is appropriate. In cases of violation of the assumption of homogeneity of variance, the Welch test is appropriate.

The second research question required a four-way ANOVA. The four-way ANOVA allows for the analysis of four independent variables. The independent categorical variables were entry-level developmental mathematics course, age, gender, and ethnicity. The dependent variable was course grade in college algebra. Again, the assumptions to check for violations were (a) approximately normal distribution and (b) homogeneity of variance. To test for normality, the skewness and kurtosis test statistic was used. The Levene's test was used to evaluate equality of variance.

To address the third through sixth research questions focused on the relationship between entry-level developmental mathematics course enrollment and demographic characteristics, persistence, and degree completion, a chi-squared test of independence was used. Specifically, the third research question was answered using a chi-squared test using levels of developmental mathematics required and persistence. For the fourth research question, entry-level mathematics and persistence was assessed by splitting the output by age, gender, and ethnicity, using a chi-squared test of independence. For the fifth question, a chi-squared test was applied using levels of developmental mathematics required and degree completion. For the sixth research question, entry-level

developmental mathematics and degree completions was assessed by splitting the output by age, gender, and ethnicity, using a chi-squared tests of independence. Chi-squared tests are used to examine if there is a relationship between two categorical variables. The assumptions of the chi-squared test are as follows (a) the data are categorical with two or more categories within each variable, (b) the variables are independent, (c) and the expected cell count for each cell is five or greater. All variables used in the third through sixth research questions were nominally or ordinally scaled with at least two categories for each variable. When the cell count was less than five, the *z* test for proportions was used instead.

CHAPTER IV

Results

The purpose of this study was to investigate the relationship between the number of developmental mathematics courses students are required to take with respect to student performance in college algebra, persistence rates, and degree completion. In particular the independent variables entry-level developmental mathematics course, gender, and age were evaluated to determine to what extent there was a relationship with the dependent variables college algebra grades, persistence, and degree completion. This chapter presents the results obtained from conducting the ANOVA and chi-squared tests to address each of the research questions.

In the Fall of 2010, there were 740 students who enrolled in at least one developmental mathematics course. Due to low enrollment in MA040 two students were removed from the data. Provided in Table 1 are the demographic characteristics for the study participants by ethnicity, gender, and lowest level developmental mathematics course. The majority of students in the study were White, there were slightly more females than males, and less than half of the students started one level below college algebra in MA120 or MA125. The student's average age was almost 20 (M= 19.94, Mdn 18.83, and SD = 3.57). The six research questions that guided this study and respective findings follow.

Table 1

Descriptive Statistics for Students Enrolled as of Fall 2010

Variable	*N*	Percent
Ethnicity		
Black	137	18.56
White	466	63.14
Hispanic	72	9.76
Other	63	8.54
Gender		
Male	345	46.75
Female	393	53.25
Lowest Level Course		
MA120/MA125	352	47.70
MA060	194	26.29
MA050	147	19.92
MA020	45	6.10

Note. $N = 738$

The first research question was focused on the extent to which students' grades in college algebra differed based on students' required entry-level developmental mathematics course. To address the question, a one-way ANOVA was planned to analyze the mean difference in college algebra grades based on student's entry-level developmental mathematics course. Prior to conducting the one-way ANOVA, descriptive statistics were run to assess the statistical assumptions of normality and homogeneity of variance. The Levene's test was used to assess homogeneity of variance

for grades in college algebra grouped by the lowest level developmental mathematics course. Levene's test was not statistically significant for lowest level developmental mathematics course (p =.105) indicating that homogeneity of variance was met. However, the distribution among sample sizes for each level of developmental mathematics was extremely unequal, of the 265 students who took college algebra, 68.68% (n =182) started in MA120 Intermediate Algebra with Review or MA125 Intermediate Algebra and only 19.25% (n =51) and 12.08% (n = 32) were enrolled in MA060 Fundamentals of Algebra and MA050 PreAlgebra respectively. Therefore, the more robust Welch test was used (Glass, 1972). The differences in mean college algebra grades based on lowest level developmental mathematics course were not statistically significant F (2, 67.14) = .74, p =.48, indicating students grades in college algebra could not be differentiated by the students placement in any particular level of developmental mathematics courses. The mean grade in college algebra was a C regardless of how many levels of developmental mathematics the student was required to take.

The second research question was focused on the extent to which students' grades in college algebra differed based on students' required entry-level developmental mathematics course and by age, gender, and ethnicity. To address the question, A four-way ANOVA was planned to analyze the difference in college algebra grades based on student's lowest level developmental mathematics course and age, gender, and ethnicity. The mean course grades in college algebra by demographic characteristics and entry-level developmental mathematics course are provided in Table 2. Prior to conducting the four-way ANOVA, statistical assumptions of homogeneity of variance and normality were assessed. The assumption of equal variance can be assumed because the Levene's

test was not statistically significant for any of the variables in the study age (p =.85), gender (p =.57), and ethnicity (p =.19). However, due to drastically disparate sample sizes, the more robust Welch test statistic was used (Glass, 1972). The Welch test indicated there was not a statistically significant difference in college algebra grade for age F (2, 29.72) =.95, p =.40, gender F (1, 249.87) = 1.78, p =.18, or ethnicity F (3, 53.38) =.59, p =.62, or lowest level developmental mathematics course F (2, 67.14) = .74, p =.48. Students' grades in college algebra could not be differentiated by age, gender, or ethnicity based on their entry-level developmental mathematics course.

Table 2

Descriptive Statistics for Mean Course Grade in College Algebra by Demographic Characteristics and Entry-level Mathematics Course

Variable	College Algebra Grade				
				95% CI	
	N	*M*	*SD*	Lower Bound	Upper Bound
Age					
18-19	222	2.39	1.06	2.25	2.53
20-24	26	2.50	1.07	2.07	2.93
25-44	17	2.82	1.29	2.16	3.48
Ethnicity					
Other	22	2.45	1.30	1.88	3.03
Black	39	2.26	.97	1.94	2.57
White	178	2.48	1.07	2.32	2.63

(continued)

Hispanic	26	2.35	1.09	1.90	2.79
Gender					
Male	117	2.33	1.07	2.14	2.53
Female	148	2.51	1.07	2.34	2.68
Lowest Level					
MA 120	182	2.46	1.06	2.30	2.61
MA 060	51	2.27	1.04	1.98	2.57
MA 050	32	2.53	1.22	2.09	2.97

The third research question was focused on the relationship between students' required entry-level developmental mathematics course and student persistence. Eight chi-squared tests of independence were conducted to examine the relationship between students required entry-level developmental mathematics course and student persistence by semester. There was not a statistically significant difference in persistence and students' required entry-level developmental mathematics course for the first year which included 3 semesters, Fall 2010, Spring 2011, and Summer 2011. Provided in Table 3 are the persistence rates and number of students who persisted each semester by lowest level developmental mathematics course.

Table 3

Persistence at BCC from Fall to Spring Semesters

	MA120 and MA125		MA060		MA050	
Semester	N	%	N	%	N	%
Spring 2011	288	81.82	158	81.44	125	85.03
Fall 2011	213	60.51	92	47.42	82	55.78
Spring 2012	197	55.97	81	41.75	75	51.02
Fall 2012	131	37.22	52	26.80	45	30.61
Spring 2013	105	29.83	41	21.13	27	18.37

Note. Initial Enrollment in MA120/125 = 352; MA060 = 194: MA050 = 147. Summer semesters were not included in this chart because persistence is typically measured from Fall to Fall or Fall to Spring and enrollment in summer is low.

The persistence was relatively stable across all levels, indicating students persisted at approximately the same rate regardless of which level of developmental mathematics the students started in. Persistence from the first semester to the second was slightly higher for students who began in MA050 (85.03%) compared to MA120 and MA125 and MA060 (81.82% and 81.44% respectively). However, there was a statistically significant difference in students' required entry-level developmental mathematics course and persistence in the fourth semester, Fall 2011, χ^2 (3) = 10.88, p =.01, V = .12, and the fifth semester, Spring 2012, χ^2 (3) = 12.13, p = .01, V = .13 as well as for students persisting in the seventh semester, Fall 2012, χ^2 (3) = 9.89, p = .02, V = .12, and the eighth semester, Spring 2013, χ^2 (3) = 14.03, p = <001. V = .14. Although there was a statistically significant difference in persistence in a few semesters after the first year, there was not a discernable pattern across most all semesters.

In semesters four, five, and seven, students in MA120/MA125 and MA050 had a statistically equivalent proportion of students persist. Specifically in the fourth semester the percentage of students who started in MA120/125 who were still persisting was 60.51%, and the percentage of students who started in MA050 that were still persisting in the fourth semester was 55.78%, this was consistent across semester four, five, and seven. Of note students who started in MA 050 were persisting at the same rate as the students who started in MA120/125 were. In the eighth semester, students whose entry-level developmental mathematics course was MA120 or MA125 persisted at a statistically higher proportion 29.83%, than students who began in MA060 21.13%, MA050 18.37%, and MA020 11.11%.

During this three year time span students who might have left for various reasons (e.g. graduated, transferred, or stopped out) were not included in the analyses for persistence. However, 109 students, who started in a developmental mathematics course in Fall 2010 graduated or obtained a certificate at some point during the nine semesters that were analyzed for persistence. To add context, 29.83% of students who started their developmental mathematics sequence enrolled in MA120/MA125 during the Fall 2010 semester were still persisting in the Spring 2013 semester (refer to Table 3). Of this same group of students who began in MA120/ MA125 in Fall 2010, 17.61% had graduated within 3 years. This group of students was not represented as persisting in this study. Similarly, 14.43% of students enrolled in MA060, 10.20% of students enrolled in MA050, and 8.89% of student enrolled in MA20 graduated or obtained a certificate at some point between Fall 2010 and Summer 2013.

The mean number of total semester's students were enrolled in by the entry-level developmental mathematics course are provide in Table 4. Students enrolled in the lowest level developmental mathematics course, MA020, persisted on average a little more than three semesters, whereas, students starting in MA120/125, MA060, and MA050 persisted an average of four semesters.

Table 4

Mean number of semesters students were enrolled by lowest level developmental mathematics course

Lowest Level in first term	*N*	*M*	*SD*
MA 120/MA125	352	4.12	2.15
MA 060	194	3.57	1.98
MA 050	147	3.78	1.97
MA 020	45	3.22	1.91

The fourth research question was focused on the relationship between students' required entry-level developmental mathematics course and student persistence by demographics (age, gender, and ethnicity). Persistence rates and required entry-level developmental mathematics course were compared by age, gender, and ethnicity over 9 semesters. Chi-squared statistical analysis were conducted to compare persistence rates for students enrolled in each level of developmental mathematics by age, gender, and ethnicity. There was no statistically significant difference in age, gender, or ethnicity for

MA020 in terms of persistence. On the whole there was no statistically significant difference for age, gender, or ethnicity across all nine semesters for students enrolled in MA050. There was no statistically significant difference in age for MA050 across all nine semesters in terms of persistence. Across most semesters men and women did not differ in their persistence for MA050, however, across three semesters there was a statistically significant difference. In Fall 2011, which was the fourth semester, females persisted at a statistically significantly higher percentage 63.41% than males 36.59%, χ^2 (1) = 4.38, p = .04, V = .17. Similarly, females persisted at a statistically significantly higher rate in the fifth semester 65.33% versus 34.66%, χ^2 (1) = 5.66, p = .02, V = .20. Overall there was no statistically significant difference in MA050 by ethnicity, except for in the Fall 2012, the seventh semester, White students persisted at a statistically higher percentage than, Black, Hispanic, or other students χ^2 (3) = 7.90, p = .05 V = 23.

Generally, there was no statistically significant difference in MA060 for age, gender, or ethnicity, except in the Fall 2012, the seventh semester, the 18-19 year old age group had a statistically higher number of students persist in MA060, χ^2 (4) = 9.52, p = .05, V = .22. There was no statistically significant difference on the whole for MA125, except for in the sixth semester, Summer 2012, females persisted at a statistically significantly higher rate than males (67.30% versus 32.69%), χ^2 (1) = 4.01, p = .05, V = .11. In the semesters where there was a statistically significant difference, the rate of persistence was around 30% higher for females than for males, other than that there was no discernable pattern in persistence by demographics, indicating overall, that student persistence could not be differentiated by any particular demographic characteristic.

The fifth research question was focused on the relationship between the students' required entry-level developmental mathematics course and degree completion. A chi-squared test for independence was conducted to examine the relationship between degree completion and students required entry-level developmental mathematics course. The results of the chi-squared test show there was not a statistically significant relationship between the entry-level developmental mathematics course and degree completion, χ^2 (4) = 6.31, p = .18, V = .09, indicating there was no relationship between degree completion and students entry-level developmental mathematics course. The completion rates for each entry-level developmental mathematics course were 17.61% for MA120/125, 14.43% for MA060, 10.20% for MA050, and 8.89% for MA 020. Students graduated at approximately the same rate regardless of the student's entry-level developmental mathematics course. As a point of reference the overall percentage of students completing degrees or certifications in 150% of normal time for the Fall 2010 cohort at Butler Community College was 21% (IPEDs graduation data).

The sixth research question was focused on the relationship between students' required entry-level developmental mathematics course and degree completion by age, gender, and ethnicity. A chi-squared test of independence was conducted to examine the relationship between students required entry-level developmental mathematics course and degree completion by age, gender, and ethnicity. There was no statistically significant relationship between lowest level developmental mathematics course and completion regardless of age, gender, or ethnicity. Therefore, the variables were not related. Students, regardless of what level of developmental mathematics they started in, graduated at approximately the same rate regardless of age, gender, or ethnicity.

CHAPTER V

Discussion, Implications, and Recommendations

The purpose of this study was to investigate the relationship between the number of developmental mathematics courses students were required to take with respect to degree completion, students' performance in college algebra, and persistence rates. The findings from this study may add to the body of knowledge for one community college in Kansas and similar colleges. The results of this study can provide meaningful information to guide administrators and policy makers to improve students' success in developmental mathematics, college-level mathematics, and ultimately, improve students' chances for successful graduation. An analysis of the data gathered will identify areas of concern to help guide faculty, staff, and administrators in future steps to take to remove obstacles in the current curriculum. Additionally, the results of this study might inform program directors to develop programs to improve student attrition rates for developmental mathematics students. Knowing more about how enrollment in the developmental mathematics course sequence affects students successful completion of a college credential will enable institutions to craft better programs for students in mathematics to increase success, retention, and graduation rates.

Summary of Results

The first research question examined the extent to which students' grades in college algebra differed based on students' required entry-level developmental mathematics course. The results were not statistically significant according to the Welch statistic, indicating students grades in college algebra could not be differentiated by the students' placement in any particular level of developmental mathematics. Students who entered

the developmental mathematics sequence at lower levels courses (2 and 3 levels below college algebra) had similar mean grades in college algebra as those who began the developmental mathematics sequence in the highest level developmental mathematics course (1 level below college algebra). The mean grade in college algebra for all students regardless of which entry-level developmental mathematics the student started in was 2.0 or a C. However, the results of this study indicated, the lower the entry-level developmental mathematics course, the lower the completion rate of college algebra, with 53.06% of students who started in MA120/MA125 one level below college algebra, 26.56% of students who started in MA060 two levels below college algebra, and 22.38% of students who started in MA050 three levels below completed college algebra.

The second research question examined the extent to which students' grades in college algebra differ based on students' required entry-level developmental mathematics course and by age, gender, and ethnicity. Again the sample sizes were extremely disparate and the results were not statistically significant according to the Welch statistic, indicating the grades in college algebra could not be differentiated by age, gender, or ethnicity based on the entry-level developmental mathematics course. The majority of students who took college algebra (n = 265) from Fall 2010 through Summer 2013, were White (67.77%), females (55.85%) between 18-19 years old (83.77%). However, only 35.91% of students in the study sample (n = 738) took college algebra. Specifically, 37.66% of the women and 33.91% of the men who started in developmental mathematics took college algebra. The ethnic distribution of students from the original cohort who took college algebra was 28.47% of Black, 47.64% White, 36.11% Hispanic, and 26.98% other. In terms of age, 38.08% of students who took college algebra were 18-19 years

old, 29.89% were between the ages of 20-24, and 34.00% were between the ages of 25-44.

In the third research question the focus of the analysis was on the relationship between students' required entry-level developmental mathematics course and student persistence. Chi-squared tests of independence were conducted to explore the difference in persistence from semester to semester and the required entry-level developmental mathematics course. Chi-squared results indicated there was not a statistically significant relationship between the levels of developmental mathematics course and student persistence for the first three semesters or for the sixth semester. However, there was a statistically significant difference for students persisting to the 4th, 5th, 7th and 8th semesters. It is interesting to note that the persistence rate from Fall 2010 to Spring 2011 declined 18.25% for MA120/MA125, 18.6% for students in MA060 and 14.1% for students in MA050. Therefore, students enrolled in the lower level developmental mathematics course, three levels below college algebra persisted at higher rates than those who were one or two levels below college algebra. Overall persistence between Fall and Spring semesters was higher than between Spring and Fall semesters. A number of students were still persisting three years later. Specifically, 29.83% who started in MA120 and or MA125, 21.13% who started in MA060 and 18.37% who started in MA050. This seems to be a little backwards due to the fact that students in MA120/MA125 would be believed to need less time to graduate than the students who started two or three levels below the college level course. This may indicate that the students in the lower level courses dropped out or stopped out.

In the fourth research question the focus of the analyses was on the relationship between students' required entry-level developmental mathematics course and student persistence by age, gender, and ethnicity. Overall the results indicated there were not statistically significantly differences between persistence and age, gender, and ethnicity based on entry-level developmental mathematics courses. Across most semesters persistence did not differ by age, however, in the seventh semester 18-19 year old students whose entry-level developmental mathematics course was MA060 persisted at statistically significantly higher rates than any other age group. Similarly across most semesters, men and women did not differ in persistence, however, for students whose entry-level developmental mathematics course was MA050, females persisted at statistically significantly higher levels in the fourth, fifth, and eighth semesters. Similarly in the sixth semester, females persisted at statistically significantly higher levels for students whose entry-level developmental mathematics course was MA120 and or MA125. Finally, across all nine semesters Black, White, Hispanic, and other ethnicities did not differ in persistence with the exception of the seventh semester where White students who started in MA050 persisted at statistically significantly higher rates than other ethnicities.

For the fifth and sixth research questions, the focus of the analyses was on the relationship between students' required entry-level developmental mathematics course and degree completion. The results of the chi-squared test for independence for the fifth research question were not statistically significant indicating there was no relationship between completion of a degree or certificate and the entry-level developmental mathematics course. Students graduated at approximately the same rate regardless of the

students' entry-level developmental mathematics course. Similarly, there results of the chi-squared test for question six were not statistically significant, indicating there was no relationship between age, gender, or ethnicity by entry-level developmental mathematics course in terms of completion.

Connections to the Literature

The results of the first two questions regarding grades in college algebra were not statistically significant in this study indicating that the grades students earned in college algebra could not be differentiated by the level of developmental mathematics course the students started in, or by age, gender, or ethnicity. Likewise, Boatman and Long (2010) examined the effects of being assigned to developmental courses on grades in college-level courses and did not find a statistically significant difference in students grades. Successful completion of college-algebra is an important milestone on the road to college completion. Developmental mathematics courses are designed to prepare students to be successful in their college level courses; however, most studies on developmental mathematics focused on persistence, degree completion, or credits earned and compared student outcomes between non-developmental and developmental students (Bettinger & Long 2009; Martorell & McFarlin, 2010).

Calcagno et al. (2006) determined that successful completion of college algebra positively impacted the likelihood of graduation for all students. Chen and Simone (2016) reported students who had completed developmental mathematics were more likely to succeed in a college-level mathematics course than students who did not take developmental courses. Bailey et al. (2009) analyzed the progression of student through the developmental sequence and reported that only 20% of the students who were

referred to a developmental mathematics course completed their college-level course, however, of the students who did enroll in gatekeeper courses, approximately 75% of them passed the gatekeeper course. As a result of their study Bailey et al. (2009) suggested the bigger issue is failure to enroll.

Although, this particular study did not compare non-developmental students to developmental students, the results of this study were similar to Bailey et al. (2009) and Ngo Kosiewicz (2017) in regard to a low percentage of students who started in a developmental mathematics course completed college algebra, and of those who did complete college algebra the average grade was a C regardless of the entry-level course to which the students were referred. Ngo and Kosiewicz (2017) indicated that nationwide 40% of students who were required to take at least one developmental mathematics course went on to complete a credit-bearing mathematics course. These results were consistent with the current study in that 39.10% of students who started in a developmental mathematics course completed college algebra. Students were included as taking college algebra if they earned an A, B, C, D or F. In Kansas, that number was much lower where only 17% of students at 2-year colleges complete the developmental sequence and associated college-level courses within two years (Kansas Board of Regents, 2012). Similarly, the CCRC conducted a study of students requiring more than two levels of developmental mathematics across multiple states, which indicated "more than 90% of these students" are lost in the course sequence and ultimately fail to enroll in the college-level mathematics course (Hern, 2012, p. 60). The percentage of students who began one level below college algebra and completed college algebra in the current study was 53.10%, 26.56% began 2 levels below and 22.38% began 3 levels below

college algebra. These results are somewhat better than the CCRC study, however, the more levels of developmental mathematics that were required resulted in a lower percentage of students who completed college algebra. The results of the current study would indicate that the greater challenge with increasing success in college algebra for BCC is getting students to enroll in college algebra.

The third and fourth research questions focused on the relationship between students required entry-level developmental mathematics course and student persistence. Although the findings in the current study were somewhat mixed they are similar to other literature on the impact of developmental education and persistence. It is important to note, that the definition and the analyses of persistence was not consistent across all studies and most studies compared persistence of students enrolled in developmental mathematics to students who were not enrolled in developmental mathematics courses, which is not consistent with the current study.

Persistence in the current study was defined as being enrolled in BCC from semester to semester and only included students who were enrolled in developmental mathematics courses in their first semester. Bettinger and Long (2005) specifically focused on persistence through the developmental mathematics sequence and compared those students who were required to take developmental courses to those who had similar backgrounds but were not required to take developmental courses. Bettinger and Long (2005) reported students in Ohio 2-year institutions who took developmental courses were more likely to persist than students who were not enrolled in remedial courses. In a study conducted by Calcagno and Long (2008) of community college students in Florida, developmental mathematics was reported to have a positive impact on persistence to the

second year of college for students on the margin placing in developmental mathematics. Crisp and Delgado (2014) on the other hand, suggested developmental education has no impact on persistence. In the current study, there was not a statistically significant difference in student persistence to the second year based on entry-level developmental mathematics course, and 55.14% of students persisted to the second year. Similarly, Wolfle (2012) reported no significant interactions between age, developmental status, or ethnicity on persistence to the second year for first-time in college students enrolled in a developmental or college level mathematics course at a Virginia Community College. Wolfle (2012) reported 50.3% of students persisted to the second year.

Overall, in the current study, no statistically significant difference was found for age, gender, or ethnicity in terms of persistence by entry-level developmental mathematics course, however, there was a statistically significant difference in four semesters. In each of those semesters, females persisted at statistically significantly higher levels than males. This was consistent with several studies (Bailey et al., 2009, Conger and Long, 2010; Davidson & Petrosko 2015).

The last two research questions in this study analyzed the relationship between degree completion and entry-level developmental mathematics. Multiple studies reported a negative association between developmental mathematics and degree completion. Boatman (2014) suggested the long sequence of developmental mathematic courses that are intended to assist students in succeeding in college algebra can pose as a barrier to degree completion. Bailey et al. (2009) indicated completion rates for developmental students are negatively associated with the number of developmental courses that they are referred to. Complete College America (2012) reported most students who enrolled in

developmental courses never graduated. Attewell et al. (2011) reported "68% of degree seeking students who began at two-year colleges had not earned a degree 6 years later" (p. 536).

The results for this study on the relationship between degree completion and entry-level developmental mathematics were not statistically significant indicating there was not a relationship between the entry-level developmental mathematics course and degree completion. These results were inconsistent with studies that suggest taking developmental courses negatively impacts degree completion (Bailey, 2009; Bailey and Cho, 2010; Boatman, 2014; Complete College America, 2012). In the current study, regardless of the entry-level developmental mathematics course students started in, degree completion rates were not different. Furthermore, the result of this study indicated there was not a statistically significant difference in student completion by, race, gender or ethnicity. These findings are contrary to studies that suggest White, Non-Hispanic developmental students (Bremer et al. 2013) and women (Conger & Long, 2010) were more likely to graduate.

Although graduation rates were low for students who took developmental mathematics courses in this study (17.61%, 14.43%, 10.20%, and 8.89% for MA120/MA125, MA060, MA050 and MA020 respectively) the overall graduation rate for all students who started in the Fall 2010 at BCC was 21%. Therefore, graduation rates in general are too low and enrollment in developmental mathematics courses should not be the only factor to consider when seeking to improve graduation rates.

Connections to Theoretical Framework

Bahr's (2013) deconstructive approach focused on how students navigate through the various stages from entering college to a number of outcomes such as completion of a credential, transfer, or college-level mathematics competency. Rather than simply identifying if a student received a credential, this approach focused on gaining a thorough understanding of student's progression or lack of progression through community colleges. Bahr's (2013) approach to research on developmental education students' progression along with Tintos (1975) theory of student departure, and Hagedorn and Kuzenetsova (2016) and, Bean and Metzer (1985) theory of non-traditional student attrition, guided the selection of variables in this study (college algebra grades, persistence, college completion, age, gender, and ethnicity). This application of research to the community college in this study helped illuminate students persistence through college algebra and to college completion.

Implications for Research and Practice

This research in this dissertation informed the mathematics redesign at BCC. Prior to this research, BCC was not able to follow cohorts of students to gain an understanding of students persistence from semester to semester, and there had not been previous studies conducted at BCC providing data on developmental students' success in college-level courses. This results of this dissertation provided baseline data and guidance in the mathematics redesign at BCC. This results of this study provide meaningful data to BCC that will aid in assessing the impact of implementing modules in our developmental mathematics sequence and college algebra courses. The results provide a broad overview of the effectiveness of the traditional developmental mathematics course sequence at

BCC, the data will be used to make data-informed decisions and make our developmental mathematics program more effective.

Further Research

Further study should include following participants who have persisted beyond three years to determine if they eventually complete a degree. In addition, a study following the students progression through the developmental mathematics sequence including; the number of attempts and grades in each developmental course, and identifying where students drop out of the developmental mathematics sequence, could be conducted to better understand at which points the students fail to persist and help identify possible reasons students do not complete a degree. Knowing where students are falling out or stopping out of the developmental mathematics pipeline and identifying links between students' characteristics and academic outcomes could help identify factors affecting developmental students' successful completion of college algebra and degree completion and provide insight that could lead to interventions to improve those outcomes. Finally, a qualitative study is needed to assess student perceptions on course taking outcomes and degree completion. Studies could be conducted to examine the effect of non-cognitive factors on student outcomes and identify factors that enable persistence and academic success for developmental mathematics students. This additional information could possibly provide strategies and best practices to increase the likelihood for degree completion.

Conclusion

When evaluating the effectiveness of a developmental education program, it is important to look at graduation and persistence rates (Boylan, 2002). As you can see

from this study, there was not a statistically significant relationship between the levels of developmental mathematics required and graduation or grades in college algebra. On the whole there was not statistically significant differences in persistence. The study goes further in showing developmental mathematics students show no statistically significant relationship based on gender or ethnicity and degree completion or grades in college algebra at the study institution. The results of this study are promising because developmental courses and particularly developmental mathematics courses have been targeted as the cause of low persistence and completion rates. Additionally, the long sequence of developmental courses is believed to create an "obstacle course" for developmental students thereby providing many opportunities for students to step out of their sequences and ultimately drop out (Bailey et al., 2009, p.13). Developmental mathematics courses and college algebra may be intimidating, and certainly there are improvements that need to be made, but there are too many factors that affect students success to lay all of the blame on developmental education.

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APPENDIX

Sam Houston STATE UNIVERSITY
A Member of The Texas State University System

Date: Mar 8, 2019 8:29 PM CST

TO: Bethany Chandler
Susana Skidmore
FROM: SHSU IRB
PROJECT TITLE: An Examination of a Developmental Mathematics Sequence at a Community College in Kansas
PROTOCOL #: IRB-2019-52
SUBMISSION TYPE: Initial
ACTION: Exempt
DECISION DATE: March 8, 2019
EXEMPT REVIEW CATEGORY: Category 4. Secondary research for which consent is not required: Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met:

(i) The identifiable private information or identifiable biospecimens are publicly available;

(ii) Information, which may include information about biospecimens, is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained directly or through identifiers linked to the subjects, the investigator does not contact the subjects, and the investigator will not re-identify subjects;

(iii) The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under 45 CFR parts 160 and 164, subparts A and E, for the purposes of "health care operations" or "research" as those terms are defined at 45 CFR 164.501 or for "public health activities and purposes" as described under 45 CFR 164.512(b); or

(iv) The research is conducted by, or on behalf of, a Federal department or agency using government-generated or government-collected information obtained for nonresearch activities, if the research generates identifiable private information that is or will be maintained on information technology that is subject to and in compliance with section 208(b) of the E-Government Act of 2002, 44 U.S.C. 3501 note, if all of the identifiable private information collected, used, or generated as part of the activity will be maintained in systems of records subject to the Privacy Act of 1974, 5 U.S.C. 552a, and, if applicable, the information used in the research was collected subject to the Paperwork Reduction Act of 1995, 44 U.S.C. 3501 et seq.

Greetings,

Thank you for your submission of Initial Review materials for this project. The Sam Houston State University (SHSU) IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

Since Cayuse IRB does not currently possess the ability to provide a "stamp of approval" on any recruitment or consent documentation, it is the strong recommendation of this office to please include the following approval language in the footer of those recruitment and consent documents: IRB-2019-52/March 8, 2019.

We will retain a copy of this correspondence within our records.

*** What should investigators do when considering changes to an exempt study that could make it nonexempt?**

VITA

Bethany Chandler

Education

Doctoral Candidate; Developmental Education Administration
Dissertation Title: *An Examination of a developmental mathematics sequence at a community college in Kansas*.
Sam Houston State University, Huntsville, Texas

M.ED Curriculum and Instruction
Wichita State University, Wichita, KS

B.S.E. Elementary Education- Mathematics
Kansas State University, Manhattan, KS

A.A. *Mathematics*
Butler Community College, El Dorado, KS

Presentations

Chandler, B., Bond, C., Bruce, L. (2019, March). *Solving the Placement Paradigm.* Presented at the Innovative Educators Summit, Isle of Palms, SC.

Bruce, L., & Chandler, B, (2019, February). *Solving the Placement Paradigm.* Presented at the Great Plains Conference on Acceleration (GPCA): Models of Success; Placement, Results, and Support. Butler Community College, El Dorado, KS.

Bruce, L. & Chandler, B., (2018, April) *Math "The Butler Way" – A Modular Approach to Curriculum Redesign.* Presented at the ACT 2018 Kansas ACT State Organization Conference: Connecting for Success. Wichita State University, Wichita, KS.

Chandler, B &Bond, C. (2018, April) Math *Modules and Placement*. Presented at a Hawkes workshop at Bowie State University. Bowie, MD.

Bond, C., Bruce, L. Chandler, B, Covert, S., (2018, March) *Math the Butler Way- A Unique Module Approach.* Presented at the Great Plains Conference on Acceleration (GPCA): Models of Success: Considering all the Variables. Butler Community College, El Dorado KS.

Chandler, B., & Bond,C. (2017, September) Butler My Math Plan Assessment. Presented as part of a Hawkes online conference for Iowa Higher Education.

Chandler, B., & Covert, S. R. (2015, February). *An examination of a developmental math sequence on graduation and persistence rates for a community college in Kansas.* Paper presented at the 38th Annual meeting of the Southwest Educational Research Association, San Antonio, TX.

Chandler, B. (2009, October). *Online Prealgebra students actually do their homework.* Presented at the 19th Annual Kansas City Regional Technology Expo