

ASSESSING THE IMPACT OF COREQUISITE REMEDIATION ON STUDENT COMPLETION IN
SELECTED GATEWAY MATHEMATICS COURSES

by

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ABSTRACT

In the last several decades, the attention of both two- and four-year institutions of higher learning have been focused on increasing the number of students who complete their gateway courses in mathematics and English. One strategy that appears to increase the number of students who complete their gateway mathematics and English courses and reduce the number of semesters it takes them to complete their gateway course is corequisite remediation.

The purpose of this study was to examine the impact of implementing a corequisite remediation model, in contrast to the traditional prerequisite remediation model, in selected gateway mathematics courses. In particular, does the use of corequisite remediation, in contrast to prerequisite remediation, (1) increase the number of students successfully completing selected gateway mathematics courses and, (2) improve the academic achievement of students, as measured by the final course grade, in selected gateway mathematics courses?

Findings from the data indicate that corequisite remediation increased the number of students successfully completing all three gateway mathematics courses included in the study with a grade of "D" or better in 2017 compared to 2016. Chi-Square tests found no significant difference in the proportion of students who successfully completed Quantitative Literacy and Introductory Statistics via corequisite remediation, compared to prerequisite remediation, with a grade of "D" or better. Additionally, Chi-Square tests revealed that there was a significant difference in the proportion of students who successfully completed College Algebra via

corequisite remediation, compared to prerequisite remediation, with a grade of “D” or better.

Finally, logistic regression analyses found that (1) students’ cumulative grade point average was predictive of success in all three gateway courses included in the study, and (2) that the type of remediation (corequisite versus prerequisite) was predictive of success in College Algebra but was not predictive of success in Quantitative Literacy or Introductory Statistics.

KEY WORDS: Corequisite remediation, developmental education, developmental mathematics

DEDICATION

To my mother, Carolyn Marlene (Miles) Ponder and father, Ulysses Ponder.

Thank you for the numerous sacrifices you both made so that me, my brothers and sisters all
had the opportunity to succeed in life.

Your generous support and love has enabled me to accomplish much in life!

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CHAPTER ONE: INTRODUCTION

INTRODUCTION

Community colleges trace their lineage as far back as the late 19th century when William Rainey Harper, founding president of the University of Chicago, came up with the concept of separating the first two years of college from the last two years of college (Kane & Rouse, 1999). Ideally, students would complete the lower division or preparatory material at a community college, or junior college as they were known at the time, and then transfer to a four-year college (Kane & Rouse, 1999). Today's 21st century community colleges essentially perform the same role as the early junior colleges in that they allow students to complete the first two years of a baccalaureate degree and then transfer to an area university to complete the last two years their program.

Community colleges have experienced significant increases in both enrollment and number. Between 1944 and 1947, community college enrollments nearly doubled due to millions of former military personnel attending college under the GI Bill (Kane & Rouse, 1999). Enrollment at community colleges continued to grow throughout the 1950s and 1960s. In fact, by the end of the 1960s, enrollment at community colleges had quadrupled (Witt, Wattenbarger, Gollattscheck, & Suppiger, 1994). When one considers the tremendous enrollment growth community colleges experienced in the early 1900s it is no wonder that Brint and Karabel (1989) noted "that this peculiarly American invention [two-year community

colleges] was destined to do far more than survive; by mid-century, it had become an integral feature of the American educational landscape” (p. v).

Like students who attended the early junior colleges of the late 19th century, many of today’s community college students intend to transfer to a four-year university once they earn their associate degree (Kane & Rouse, 1999). In addition, Kane & Rouse go on to add that today’s comprehensive community colleges have broadened their mission to include vocational degree programs, adult education programs, and workforce development.

One sector that struggles to fill its needs for a skilled workforce is manufacturing. Across the United States, thousands of manufacturing jobs remain unfilled. Although some manufacturing jobs lack placement due to an inability of companies to find the right candidates, many Americans lack the necessary skills to fill these openings (Gillespie, 2016). The difference between the skills employers want and the skills possessed by workers looking for a job is known as the skills gap (“The Skills Gap”, n.d.). How significant of a problem does this gap pose? In 2011, 600,000 jobs were unfilled due to the skills gap, according to the Manufacturing Institute and Deloitte (Carrick et al., 2015). What is even more troubling though, according to a 2015 study conducted by the Manufacturing Institute and Deloitte, the skills gap is worsening (Carrick et al., 2015). To illustrate, nearly 3.5 million manufacturing jobs are predicted in the next 10 years but only about 1.4 million jobs are likely to be filled so by 2025 the skills gap is expected to cause approximately two million manufacturing jobs to go unfilled (Carrick et al., 2015).

Education is the key to solving the skills gap. According to the Lumina Foundation, 60 percent of working adults age 25 - 64 must possess a high-value post-secondary certificate or

degree by 2025 in order to meet the nation's growing need for talent ("Goal 2025," n.d.).

Currently, the United States is on track to produce approximately 24.2 million Americans with postsecondary credentials by 2025 but to reach Goal 2025, an additional 16.4 million Americans would need to be added to that total ("Goal 2025"). According to a report published by the National Student Clearinghouse Research Center, for the 2010 cohort of students only 39.3 percent of the students who started at a two-year public institution completed a degree or certificate within six years with 62.4 percent for student who began at a four-year public institution (Shapiro et al., 2016). So, higher education, and in particular, community colleges, must produce more graduates who possess either a certificate or a degree; if more Americans are to gain the skills needed to enter the workforce.

Most, if not all undergraduate programs require students to complete one or more mathematics courses to ensure that students have attained some minimum level of quantitative literacy. Students that do not test as college-ready may be required to take one or more courses in developmental or remedial education. Although Phipps (1998) described remedial education as the courses and support services designed to provide basic skills to a broad population of diverse and underprepared students Boylan and Bonham (2007) state that "Developmental education refers to a broad range of courses and services organized and delivered in an effort to help retain students and ensure the successful completion of their postsecondary education goals" (p. 2). While acknowledging that there are times when it may be more appropriate to say "developmental" education rather than "remedial" education, for the purposes of this study, both "remedial education" and "developmental education" will be used interchangeably.

In 2011 - 12, 29 percent of first- and second-year bachelor's degree students at public four-year institutions and 41 percent of first- and second-year bachelor's degree students at public two-year institutions reported taking remedial courses after high school (Skomsvold, 2014). Moreover, the Ohio Board of Regents (OBOR) notes that in the 2004 – 2005 fiscal year, approximately 37 percent of all first-year students attending a two- or four-year institution in Ohio took at least one remedial course in mathematics or English (Ohio Board of Regents, 2007). Additionally, "among 2003-04 beginning postsecondary students, 68 percent of those starting at two-year institutions and 40 percent of those starting at four-year institutions took at least one remedial course during their enrollment between 2003 and 2009" (Chen, 2016, p. iv). Finally, data from the U.S. Department of Education indicates that 42 percent of freshmen students entering public two-year institutions in 2000 were in need of at least one developmental (reading, writing or mathematics) course (Parsad & Lewis, 2003).

Since the purpose of developmental education is to prepare students to succeed in college level coursework, what is the relationship between remedial education and completion of both college-level coursework and degree completion? According to a study conducted by the Ohio Board of Regents of a 1998 cohort of first-time freshman students, students who took remedial courses were less likely to earn degrees (Ohio Board of Regents, 2007). Moreover, a study by Chen (2016) of remedial course takers beginning at public two-year institutions in 2003 – 04 found that 49 percent completed all of the remedial courses they attempted with 59 percent for those students beginning at public four-year institutions. In addition, this same study found that 71 percent of remedial math completers took college-level math courses, and 62 percent of them earned some credits in those courses (Chen, 2016). However, 32 percent of

non-completers (students who did not complete their required remedial math courses) took college-level math courses and 18 percent of those students earned some credit in those courses (Chen, 2016). Thus, among 2003 – 04 beginning postsecondary students who first enrolled in public two-year institutions, 67 percent of remedial non-completers and 35 percent of remedial completers had left postsecondary education without a degree or certificate (and had not returned) by 2009 with 44 percent and 22 percent respectively for students who began at public four-year institutions (Chen, 2016).

In April 2012, the American Association of Community Colleges (AACC) joined with other national organizations such as the Center for Community College Student Engagement (CCCSE) and the League for Innovation in the Community College to express a shared commitment to student completion by establishing the goal of producing 50 percent more students with high-quality degrees and certificates by 2020 (“The Completion Agenda”, 2011). The challenge issued by AACC and other organizations to increase the number of degree and certificate holders being produced by higher education institutions has become so popular in higher education circles that this challenge is now commonly referred to as the “Completion Agenda.”

A key area of focus of the Completion Agenda is increasing the number of students who complete required gateway courses in English and math; preferably in two semesters or less. For the purposes of this study, a *gateway* English or math course is the first college-level course required by the student’s program of study. According to the Complete College America website (2011), 51.7 percent of students entering a two-year college enroll in remedial courses, but only 22.3 percent of those students complete both their remedial and gateway courses in

two years, while only 9.5 percent of those students graduate with their associate degree within three years (“Corequisite remediation,” n.d.).

One reason why so few students complete their required gateway course is because the traditional model of prerequisite remediation requires students to enroll in long sequences of remedial English and math courses. As a result, the majority of students in these long, remedial course sequences do not successfully complete the sequence and ultimately leave the institution without earning a credential. Hence, alternatives to the traditional model of prerequisite remediation which 1) increase the number of students who successfully complete gateway courses in English and mathematics and 2) reduce the amount of time it takes students to complete their required gateway course are being explored with the ultimate goal being to increase the number of students earning a postsecondary credential.

One strategy that appears to increase the number of students who complete their gateway mathematics and English courses and reduce the number of semesters it takes to complete their gateway course is corequisite remediation. Corequisite remediation is a strategy that allows students to enroll in their gateway course while taking a developmental English or math course at the same time (“Corequisite remediation: Spanning the divide,” n.d.). While students are enrolled in the developmental course, the prerequisite skills and knowledge needed to succeed in the gateway course are reinforced. In addition, time management skills, study skills, and “wrap-around” support services such as academic advising or counseling services are often embedded in the developmental course on a “just in time” basis (“Corequisite remediation: Spanning the divide,” n.d.) to further support the success of these students.

Many schools implement corequisite remediation as part of a paradigm shift from prerequisite remediation to an approach in which students are directly placed in required gateway courses with high levels of focused support provided by both academic and student support services at the institution (“Core principles for transforming,” n.d.). This shift is occurring, at least in part, due to the belief that students are more engaged and will do better when they are enrolled in classes that count toward their degree or certificate (“Core principles for transforming,” n.d.) and the recognition that long sequences of developmental coursework are ineffective since many students never even get the opportunity to enroll in their gateway English or mathematics course.

STATEMENT OF THE PROBLEM

According to Complete College America, “time is the enemy of college completion” (“Time is the enemy”, n.d., para. 1). In other words, the longer it takes for a given student to earn a postsecondary certificate or degree, the greater the chance that life’s challenges or some other obstacle may prevent the student from obtaining a postsecondary credential (“Time is the enemy”, n.d.). Although each year tens of thousands of students complete their gateway mathematics courses via traditional prerequisite remediation, this model forces students to take as many as two or three semesters of developmental courses before being eligible to take their required gateway course. Prerequisite remediation takes precious time that students do not have. Moreover, data show that large numbers of students never have the opportunity to enroll in gateway English and math courses due to long course sequences which rely on prerequisite remediation. In contrast, corequisite remediation reduces the

number of terms (or time) it takes for students to complete a gateway course since it allows students to enroll in their gateway course while co-requisitely taking a developmental course. Granted in some cases, a student may still be required to complete a developmental course (via prerequisite remediation) before enrolling in the required gateway course paired with a developmental course. However, even in this scenario, it is possible for a student to complete his or her required gateway mathematics courses in one academic year, or two semesters. Thus, the problem under examination is the large number of students who fail to complete their sequence of developmental courses and/or their gateway mathematics courses via traditional prerequisite remediation.

PURPOSE OF THE STUDY

The purpose of this study was to examine the impact of implementing a corequisite remediation model, in contrast to the traditional prerequisite remediation model, at a large, urban, community college located in the downtown business district of the sixth largest city in the State of Ohio. In particular, does the use of corequisite remediation, in contrast to prerequisite remediation (1) increase the number of students successfully completing selected gateway mathematics courses and, (2) improve the academic achievement of students, as measured by the final course grade, in selected gateway mathematics courses?

RESEARCH QUESTIONS

The following research questions in this quasi-experimental design guided this study:

1. Research Question 1 (RQ1)

Does corequisite remediation, as compared to prerequisite remediation, increase the number of students successfully completing selected gateway mathematics courses in the 2017 Spring Semester compared to the 2016 Spring Semester with a grade of “D” or better?

2. Research Question 2 (RQ2)

Was there a significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to the proportion of students who successfully completed the same course with a grade of “D” or better via prerequisite remediation?

3. Research Question 3 (RQ3)

For students flagged as a Performance Based Funding Eligible Minority (PBFEM) enrolled in selected gateway mathematics courses, was there a significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better via corequisite remediation (Booster students) compared to the proportion of PBFEM students who successfully completed the same course with a grade of “D” or better via prerequisite remediation (Non-booster students)?

4. Research Question 4 (RQ4)

For students enrolled in selected gateway mathematics courses, was there a significant difference in the proportion of Non-Performance Based Funding Eligible Minority (Non-PBFEM) students who successfully completed the course via corequisite remediation (Booster students) with a grade of “D” or better, compared to Non-Performance Based Funding Eligible Minority (Non-PBFEM) students who successfully completed the course via prerequisite remediation (Non-booster students) with a grade of “D” or better?

5. Research Question 5 (RQ5)

For students enrolled in selected gateway mathematics courses who were flagged as ever being eligible to receive a Pell grant, was there a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students)?

6. Research Question 6 (RQ6)

For students enrolled in selected gateway mathematics courses who have not been flagged as ever being eligible to receive a Pell grant, was there a significant

difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students)?

7. Research Question 7 (RQ7)

For students enrolled in selected gateway mathematics courses, does the type of remediation (corequisite remediation versus prerequisite remediation) predict academic achievement in selected gateway mathematics courses, as measured by the Final Course Grade (FCG), while controlling for the student’s Grade Point Average (GPA) and the student’s Initial Math Placement Level (IMPL)?

CONCEPTUAL FRAMEWORK

The conceptual framework for remediation, and in particular, remedial or developmental mathematics, is grounded in the theory of scaffolding which arose out of Lev Vygotsky’s zone of proximal development (Brower et al., 2017). The zone of proximal development (ZPD), according to Vygotsky (1978), may be defined as “the distance between the actual developmental level [what the student currently knows and is able to do without guidance], as determined by independent problem solving, and the level of potential development [the next attainable level or goal], as determined through problem solving under adult guidance, or in collaboration with more capable peers” (p. 86). Hence, the scaffolding of academic and student support services, inherent in developmental mathematics, is the framework by which instruction and/or guidance may be provided by an instructor, academic advisor, counselor, tutor, or peer tutor to assist students to move from the Zone of Current Development (ZCD), or what the student currently knows and is able to do independently, through the Zone of Proximal Development (ZPD) and therefore reach a level of development, where he or she is able to independently solve problems (Harland, 2003; Wass, Harland, & Mercer, 2011); ultimately in the college-level math course.

In the context of corequisite remediation, scaffolding can be used to provide students with needed support while the student is enrolled in both the college-level math course and the developmental math course. In addition to the various foundational skills and concepts which are needed to support the student's learning and understanding of the college-level material, a variety of other supports are also "scaffolded" into the student's learning experience; such as test taking skills, note taking skills, collaborative learning, peer tutoring, and information about support services provided by the institution. So, while the student is learning the college-level content, developmental content and wrap-around support services are scaffolded in an intentional, collaborative, and just in time manner; greatly enhancing the student's learning experience through the ZPD. So, by the end of the semester, the student has advanced to the point that he or she is able to demonstrate mastery of the material in the college-level math course completely independent of the scaffolding; and the learning process of moving through the ZPD begins again (Vygotsky, 1978; Harland, 2003).

Scaffolding may also be explained in the context of prerequisite remediation. With prerequisite remediation, the concepts and skills needed to succeed in a given course are "front-loaded" in the prerequisite course. Take for example College Algebra. The foundational concepts and skills needed for a student to succeed in College Algebra are typically taught in a course known as Intermediate Algebra. So, once a student successfully completes Intermediate Algebra, it is assumed that he or she is sufficiently prepared to take College Algebra.

At the research site, all of the math courses included in the study were delivered in a lecture-based format that left little time to 1) reinforce prerequisite skills, 2) provide detailed explanations of the relationship between the prerequisite material and the college-level

material being discussed on a given day of class and, 3) regularly engage in collaborative, problem-solving activities. Ultimately, even the most student-centered faculty is constrained by the simple fact that he or she has a set amount of content that must be delivered within a certain amount of time. Thus, at some point during class, the faculty must begin covering new material even if there are students in the class who have not mastered the material discussed at the last class meeting. Unless these students seek out additional assistance, they risk having gaps in their understanding of key mathematical concepts. These gaps could lead to the students receiving a failing grade in the class. One of the key weaknesses of prerequisite remediation, as a model, is that it assumes any student who successfully completes a course prerequisite is adequately prepared for the next course in the sequence without the need for additional remediation. In contrast, corequisite remediation, as a model, provides instructors the ability to introduce topics from gateway mathematics courses with the added flexibility to provide additional remediation on prerequisite content (or in some cases teach a concept from scratch) while better leveraging the institutional supports at the instructor's disposal in a just in time manner. Ultimately, this study seeks to demonstrate that the scaffolding inherent in corequisite remediation is superior to that of prerequisite remediation since corequisite remediation has the potential to 1) increase the number of students successfully completing gateway courses in mathematics and 2) improve the academic achievement of students in gateway mathematics courses.

Finally, it should be pointed out that Vygotsky originally applied his ZPD theory to the sociocultural development of children and he never used the term "scaffolding" (Brower et al., 2017). However, ZPD theory has been applied in studies on developing critical thinking skills

(Wass, Harland, & Mercer, 2011), ZPD theory has been used to support a student-centered approach to corequisite remediation which leveraged a developmental mathematics lab (Atkins, 2016), and ZPD theory has been used as framework for studying mathematics remediation of at-risk students (Brower et al., 2017).

INSTITUTIONAL BACKGROUND

The research for this study occurred in the spring semester of 2017 at a large, publicly funded, community college located in the downtown business district of the sixth largest city in the State of Ohio. The institution serves more than 30,000 unique students each calendar year, spread across five separate locations. In addition, more than 25 percent of the total enrollment at this institution is comprised of online students. Finally, the college utilizes an open enrollment admissions policy and more than half of all credit-based instruction at the institution is provided by full-time faculty.

SIGNIFICANCE OF THE STUDY

This study contributes to the body of knowledge focused on improving student completion of gateway mathematics courses by (1) assessing the impact of corequisite remediation, in contrast to prerequisite remediation, on increasing the number of students who successfully completed selected gateway mathematics courses and (2) assessing the impact of corequisite remediation, in contrast to prerequisite remediation, on improving student achievement, as measured by students' final course grade in selected gateway mathematics courses, and (3) by examining whether the type of remediation (corequisite versus prerequisite) is predictive of student completion in selected gateway mathematics

courses while controlling for student's initial mathematics placement level and their cumulative grade point average.

Increasing the number of students who complete gateway mathematics courses is often a key component of an institution's overall strategy to increase the number of students who earn high-quality certificates or degrees, which in turn is key to closing the skills gap. Thus, the results of this study have the potential to inform both faculty and administrators at other institutions of higher learning as to how they may improve overall completion rates of students, thereby increasing the availability of a skilled workforce.

OPERATIONAL DEFINITIONS

For the sake of both consistency and convenience, a list of key terms, and their definition, that were used throughout the study has been provided below.

Academic achievement/performance — Refers to the performance of students in the gateway mathematics course as measured by the final course grade. In this study, academic achievement/performance in the context of success will mean students successfully completing a gateway mathematics course with a grade of "D" or better.

Academic year — Academic year, or regular academic year, typically means the fall and spring semester, but does not include the summer semester.

Corequisite remediation — A type of course remediation in which a student enrolls in a college-level or gateway course while taking a developmental or "booster" course at the same time. Typically, the booster course is an abbreviated version of the course which serves as the immediate prerequisite to the gateway course.

Developmental education — Boylan and Bonham (2007) state that "Developmental education refers to a broad range of courses and services organized and delivered in an effort to help retain students and ensure the successful completion of their postsecondary education goals" (p. 2). For the purposes of this study, the terms developmental education and remedial education will be used interchangeably.

Gateway course success — For the purposes of this study, gateway course success refers to a student earning a grade of “D” or higher in the first college-level English or math course required by the student’s program of study.

Pell Grant — A type of financial aid awarded by the federal government. Typically, Pell funding is awarded to students whose families make less than \$50,000 annually (“Federal Grants”, n.d.).

Pell-eligible — Students who were flagged as ever being eligible to receive a Pell grant at any point in time while enrolled at the research site. In this study, the phrases “Pell-eligible” or “ever Pell” will be used interchangeably. Similarly, any student who was not flagged as ever being eligible to receive a Pell grant at any point in time while enrolled at the research site will be referred to as Non-Pell or Non-Pell eligible.

Performance Based Funding (PBF) — Performance-Based Funding refers to a funding model utilized in the State of Ohio in which the flow of revenue or State Share of Instruction (SSI) from the state to the Higher Education Institution (HEI) is based on a variety of completion metrics, such as the number of credits earned, the number of certificates or degrees awarded, or whether a student completed a gateway English or mathematics course. It should be noted that in Ohio’s PBF model, success is defined as a student earning a grade of “D” or higher in a given course.

Performance-based Funding Eligible Minority (PBFEM) Student — Any student at the research site who self-identified his or her race/ethnicity as either African-American, American Indian, or Hispanic. So, in this study, any student who did not identify his or her race or ethnicity as either African-American, American Indian, or Hispanic will be referred to as a Non-PBFEM student.

Prerequisite remediation — A type of remediation in which a student must complete the prerequisite course (typically with a grade of “C” or better) before being permitted to enroll in the next course in the sequence. For example, if Intermediate Algebra serves as the course prerequisite to College Algebra then a student must first complete Intermediate Algebra (with a grade of “C” or better) before being permitted to enroll in College Algebra.

State Share of Instruction (SSI) — The primary mechanism of “subsidizing the instructional costs at Ohio’s public institutions of higher education for the purpose of reducing the cost of tuition for Ohio residents” (“Ohio Department of Higher Education,” 2017, para. 2).

Type of Remediation (TOR) — An independent variable used to indicate whether a student enrolled in a course as a result of satisfying the course prerequisite (prerequisite remediation) or whether a student enrolled in both a gateway mathematics course and a developmental mathematics or Booster course at the same time. TOR = 0 for a

student who utilized prerequisite remediation (Non-Booster student) or TOR = 1 for corequisite remediation (Booster student).

INSTITUTIONAL POLICIES

One Year Time Limit on Math Prerequisites — At the institution which participated in this study, students registering for a math (MAT) course are required to have completed the prerequisite course not more than one calendar year prior to the semester in which they take the given mathematics (MAT) class (One Year Time Limit on Math Prerequisites, n.d.). For example, for a student to register for College Algebra (MAT 1470) in the Spring of 2017, that student must have taken the prerequisite course Intermediate Algebra (MAT 1370) no earlier than the Spring of 2016. However, with corequisite remediation, the same student may register for both College Algebra (MAT 1470) and College Algebra Booster (MAT 0470) in the Spring of 2017 if the student has completed Beginning Algebra (MAT 1270) no earlier than the Spring of 2016 (One Year Time Limit on Math Prerequisites, n.d.).

Prerequisites — “Some beginning or advanced courses have prerequisites which are other courses that must be successfully completed first. Many beginning classes require the placement test or completion of developmental courses before students may enroll in them” (Prerequisites, n.d., Para 1). At the research site, students must earn a grade of “C” or better in the math course(s) that serves as the immediate course prerequisite to another math course.

DELIMITATIONS

The following delimitations were identified by the researcher:

- Data was collected from a single institution due to the researcher’s familiarity with the institution.

- Institutional-level data from both the 2016 Spring Semester and the 2017 Spring Semester was used in this study.
- The researcher limited the scope of the investigation to face to face or classroom sections of Beginning Algebra (MAT 1270), Intermediate Algebra (MAT 1370), Intermediate Algebra 1 (MAT 1355), Intermediate Algebra II (Mat 1365), College Algebra (MAT 1470), College Algebra Booster (MAT 0470), Introductory Statistics (MAT 1450), Introductory Statistics Booster (MAT 0450), Quantitative Literacy (MAT 1445), Quantitative Literacy Booster (MAT 0445), and Excursions in Mathematics (MAT 1440), since online versions of the booster sections were not offered by the institution in the 2017 Spring Semester. Additionally, the researcher will consider the phrases Quantitative Literacy and Quantitative Reasoning as interchangeable.
- Prior to the 2017 Spring Semester, both Excursions in Mathematics (MAT 1440) and Quantitative Literacy (MAT 1445) were offered by the institution as transfer-level, liberal arts math courses. Since, MAT 1440 and MAT 1445 were designed to fulfill the same program outcomes, for the purposes of comparison, enrollment and/or completion data for MAT 1440 was used in any term in which enrollment and/or completion data for MAT 1445 did not exist; and vice versa. In other words, the researcher is assuming that these two courses are essentially equivalent since MAT 1445 was designed to replace MAT 1440.
- As mentioned previously, the college where the study was conducted utilized a policy known as the One Year Time Limit on Mathematics Prerequisites (One Year Time Limit on Math Prerequisites, n.d.). With this policy, a student may only enroll in a course if he or she has completed the course prerequisite within the last three semesters. To illustrate, a student may enroll in Course B, Spring Semester 2017, if he or she has completed the prerequisite to Course B in one of the following terms: Fall 2016, Summer 2016, or Spring 2016. The goal of this policy is to ensure that students are not able to enroll in a math course if it has been more than one calendar year since completing the course prerequisite. That said, the policy does allow any student to request and receive a one-time exception to the policy for any reason. Hence, the number of exceptions that may have been granted to the One Year Time Limit on Mathematics Prerequisites policy (Prerequisites, n.d.) may be a delimitation of this study. Moreover, students who may have been granted an exception to the policy were not excluded from this study. Future studies at this institution could lessen the impact of the policy by excluding any student from the study that received an exception to the policy.

SUMMARY

As a largely American invention dating back to the late 19th century (Kane & Rouse, 1999), community or junior colleges have played a key role in providing millions of students' access to higher education and thereby have the opportunity to earn a post-secondary credential. In fact, the National Center for Education Statistics (NCES) reports that approximately 6.3 million students were enrolled in public, two-year, Title IV institutions in the United States (50 states and the District of Columbia) in fall 2015, compared to 8.4 million students enrolled at public, four-year, Title IV institutions during the same time period (Ginder, Kelly-Reid, & Mann, 2017). Moreover, the low tuition rates associated with community colleges also drives students to attend them compared to their four-year counterparts. For example, in 2016 – 17, the average published tuition and fees for full-time students at public two-year institutions nationally was \$3,520, compared to \$9,650 at public four-year colleges ("Average published," n.d.). The open-access admission practices common to most community colleges as well as the low cost of their tuition have provided millions of individuals in the United States the opportunity to earn a postsecondary credential.

Community colleges have provided millions of students the opportunity to obtain a postsecondary credential. But if four-year institutions have an affordability problem, two-year institutions have a completion problem. The reality is that a significant number of community college students lack the necessary foundational skills in English and mathematics, and as a result are required to complete long sequences of developmental coursework via prerequisite remediation before attempting their required gateway courses in English and mathematics. Sadly, many of these students never reach their gateway courses and subsequently fail to

obtain a postsecondary credential. Chapter Two will examine the following: relevant literature regarding developmental education, attempts to reform developmental education, and different models of remediation.

CHAPTER TWO: REVIEW OF LITERATURE

INTRODUCTION

For years, a considerable amount of financial and human resources has been allocated to developmental education programs at higher learning institutions across the United States. A 1998 study estimated the national cost of developmental education to be at least \$1 billion, and a more recent study estimated the cost to be as high as \$1.13 billion based on data from 2004 – 05 (Breneman, Abraham & Hoxby, 1998; Pretlow & Wathington, 2011). The use of these resources has one purpose, namely, to support student completion of developmental courses.

Why is student completion of developmental courses so important? The simple fact is that large numbers of students who place into developmental courses, such as beginning algebra, do not achieve their educational and career goals because they never complete their developmental courses (Bonham & Boylan, 2011). In fact, Bailey (2008) states that, “Developmental education is one of the most difficult issues confronting community colleges” (p. 1). Hence, the purpose of this chapter was to review the relevant literature on the following topics: (1) the need for developmental education, (2) reforming developmental education, and (3) corequisite remediation as a central element in the redesign of developmental mathematics.

THE NEED FOR DEVELOPMENTAL EDUCATION

Placement tests allow institutions to determine whether students are ready to do college-level work (Capt, Oliver and Engel, 2014). A report by Parsad and Lewis (2003), indicated that at least 63 percent of public, two-year institutions across the country rely on high-stakes placement tests such as Accuplacer to determine college readiness in the areas of English, mathematics and writing. There are five core tests in Accuplacer. These tests are delivered in a multiple-choice format and assess students in the following areas: reading comprehension, sentence skills, arithmetic, elementary algebra, and college algebra. The average time an examinee takes to complete one of these tests in Accuplacer is 30 minutes (College Board, 2004). Hence, the average examinee can likely complete Accuplacer's five core tests in two to three hours. Armed with this information, an academic advisor or an admissions specialist at a college would then discuss a student's career goals, determine an appropriate academic program and map out a student's schedule in as little as 45 minutes. Thus, when it comes to placement tests, accuracy and efficiency are necessary.

The National Postsecondary Student Aid Study of 2003-04 highlights the fact that 42.9 percent of first- and second-year undergraduate students enrolled in public, two-year colleges reported taking at least one remedial course during the 2003-04 school year (Horn & Nevill, 2006). In addition, Bettinger and Long (2005) found that approximately 55 percent of traditional age, first-time freshmen at Ohio community colleges enrolled in remedial courses. Finally, data collected as part of the Achieving the Dream initiative indicated that approximately 59 percent of students who participated in the initiative enrolled in at least one developmental course (Bailey, Jeong, & Cho, 2010).

Clearly, large numbers of students at both two- and four-year institutions take developmental education courses. Moreover, research indicates that a significant proportion of the enrollment in developmental courses are from underrepresented populations; namely, low-income and minority students. For example, a study conducted by Bettinger and Long (2005) in Ohio found that more than 75 percent of black and Hispanic students were placed in remedial math courses compared to only 55 percent of white students. According to Attewell, Lavin, Domina, and Levey (2006), supporters of college remediation believe that students of color and students from low income families, among others, are overrepresented in remedial courses. A 2014 study by Fernandez, Barone, and Klepfer indicated that female and minority students were more likely to enroll in developmental education courses at community colleges compared to their white, male counterparts. A study by Nora and Crisp (2012) found that Hispanic students enrolled at community colleges were more likely to enroll in developmental mathematics compared to their four-year counterparts. Finally, a study by Brathwaite and Edgecombe (2018) found that a disproportionate percentage of black students and students with a low socioeconomic status were assigned to developmental education and Logue (2017) asserted that students in need of developmental mathematics courses are disproportionately students from underrepresented populations that included students of color and students with a low socioeconomic status.

On the surface, the notion of requiring students to sequentially complete a series of courses designed to increase their foundational skills in English, mathematics, and writing makes intuitive sense. But data shows that large numbers of students assigned to developmental courses are failing or otherwise not completing these courses and that students

from underrepresented populations are disproportionately assigned to developmental education. Moreover, Bailey (2009) notes that students who are placed two to three levels below their college-level course rarely complete their required gateway course and are even less likely to earn a degree. The following pages will examine recent efforts to reform developmental education.

REFORMING DEVELOPMENTAL EDUCATION

Achieving the Dream Initiative

Achieving the Dream (ATD) is a national, nongovernmental reform movement that strives to support the efforts of community colleges as they, in turn, provide their students with the opportunity to achieve their dreams through higher education (Achieving the Dream, 2018). Although the initiative seeks to positively impact the lives of all community college students the initiative places particular emphasis on positively impacting the success of both low-income students and students of color. (Rutschow et al., 2011). According to Rutschow et al. (2011), 26 colleges from five states were in the initial cohort of Round 1 colleges in 2004. As of 2017, ATD boasts a network of more than 200 institutions of higher education located in 39 states and the District of Columbia (Achieving the Dream, 2018).

“Achieving the Dream helps community colleges build a ‘culture of evidence’ by using student records and other data to examine students’ performance over time and to identify barriers to academic progress” (Rutschow et al., 2011, p. iii). To accomplish these goals, ATD uses a variation of the Plan-Do-Study-Act model. By following this model, Rutschow et al. adds that ATD colleges would develop strategies which would lead to improved student success and

completion, test these strategies (possibly by implementing small-scale pilots), and then bring effective strategies to scale (2011). The ultimate goal of these efforts was to positively impact five measures of student success; namely, 1) completion of developmental coursework, 2) completion of gateway English and math courses, 3) completion of attempted courses with a grade of “C” or better, 4) term to term and year to year persistence, and 5) completion of certificates and/or degrees (Rutschow et al., 2011).

The 26 Round 1 schools implemented 187 strategies which may be broadly classified as focusing on either student support services, instructional supports or changes in classroom instruction (Rutschow et al., 2011). Rutschow et al. (2011) adds that common types of curriculum-based interventions that were implemented included either learning communities or the use of web-based programs such as MyMathLab or EducoSoft to provide supplemental learning support.

Although about 25 percent of direct strategies by ATD schools focused on changing classroom instruction (Rutschow et al., 2011), one of the most innovative, curriculum-based strategies that was implemented as a result of or parallel to the Achieving the Dream initiative was the “modularization” of mathematics curricula. This method of delivering mathematics content came to be known as the Emporium Model. In most cases, topics from arithmetic and pre-algebra through intermediate algebra were modularized. However, some colleges modularized their entire mathematics curriculum up to and including college algebra, statistics and business calculus. Modularized curricula typically utilized a mastery learning concept, relied heavily on computerized instructional tools like MyMathLab or ALEKS, required large computer labs staffed with faculty, lab coordinators and tutors, and were generally viewed as

more cost-effective for colleges and universities than traditional lecture-based instructional methods. Ultimately, colleges and universities implemented emporium models because they were perceived to be cheaper and increased student success compared to other instructional methods.

The concept behind modularizing a curriculum is quite simple. Suppose a typical developmental math sequence at a community college is comprised of three, semester-long courses, with each course being worth three semester hours, such as pre-algebra, beginning algebra, and intermediate algebra. In an emporium model, these three courses could be divided into four modules per course for a total of 12 modules with prealgebra comprising modules one through four, beginning algebra comprising modules five through eight and intermediate algebra comprising modules nine through twelve (“Changing the Equation,” n.d.). Students who completed intermediate algebra (module 12) would be permitted to enroll in a gateway mathematics course like College Algebra or Introductory Statistics.

Based on a student’s score on a placement test, he or she could theoretically begin at any point in the curriculum from pre-algebra to intermediate algebra. Students requiring a significant amount of remediation would start with the first module while students deemed “almost” ready to take college algebra might only be required to take the twelfth module. Perhaps the single greatest advantage of a modularized curriculum is that highly motivated students would be able to complete multiple courses in a single semester. For example, if a student registered for beginning algebra and completed modules five through eight before the end of the semester, he or she would be permitted to start module nine and perhaps complete module 12 by the end of the semester.

Institutions began modularizing their curriculum as a completion strategy for students who may have been doing quite well in a course but then perhaps failed the last portion of a course because life got in the way of their studies or because their learning hit a roadblock. Typically, a student that failed or withdrew from a course would have to retake the entire course next semester. However, a student who was enrolled in the modularized curriculum described above that successfully completed modules five and six of beginning algebra in a given semester but did not complete modules seven and eight would only be required to take modules seven and eight if he or she enrolled in next semester. Moreover, if the student completed modules seven and eight before the end of the semester, he or she would then start module nine with the goal of completing the remaining modules comprising intermediate algebra before the end of the semester. Another advantage of a modularized curriculum is that it allows faculty to spend more time providing individualized assistance to students where and when it is needed to address specific weaknesses, as opposed to reviewing and discussing concepts that students already understand (Twigg, 1999).

Virginia was an early adopter of the emporium model. As part of Virginia's redesign, content from arithmetic through intermediate algebra was divided into nine, one-credit hour modules that were offered in four-week courses. An analysis of the dataset provided by the Virginia Community College System (VCCS) which was comprised of 20,572 first-time-in-college (FTIC) students who began in one of the state's 23 community colleges in Fall 2012 found that pass rates in stand-alone courses or modules ranged from 59 to 76 percent, that only 18 percent of students who placed in modules one through five attempted a gateway course

within one calendar year, and that students were likely to either “stop-out” between modules or fail to re-enroll in modules (Bickerstaff, Fay, & Trimble, 2016).

The researcher’s own personal experience with emporium models confirms the lessons learned at other Achieving the Dream institutions; namely, that emporium models utilize a personalized approach to learning since students only take the content or modules they need, incorporate mastery-learning of course content and provide students the opportunity to accelerate through developmental material. However, the modularized nature of emporium models can lead to slower student progression through developmental math requirements when students fail to enroll in the next module, even after successful completion of the previous module (Bickerstaff, Fay, & Trimble, 2016). To address this behavior, the VCCS plans to incorporate strict deadlines for module completion and working to ensure that students are matched to the best available modality (Bickerstaff, Fay, & Trimble, 2016).

Data from Round 1 schools show that they failed to make significant progress on Achieving the Dream’s five indicators of student success (Rutschow et al., 2011; Mayer et al., 2014). When the baseline cohort of students at Round 1 colleges from 2002 – 2004 is compared to the 2007 cohort of students from Round 1 colleges, the following results, which were not statistically significant, were obtained: the percentage of students who attempted a developmental math course within the first two years decreased from 75.8 percent to 70.1 percent, the percentage of students who completed their developmental math requirement within the first two years increased from 21.0 percent to 25.2 percent, the percentage of students who successfully completed a gatekeeper math course within the first two years decreased from 15.9 percent to 15.5 percent, and the percentage of students who successfully

completed a gatekeeper math course within the first two years (among students referred to developmental math) decreased from 14.3 percent to 12.2 percent (Rutschow et al., 2011).

The inability of Round 1 schools to significantly impact student completion of both developmental and gateway math courses calls into question whether the use of learning communities, student success courses, and computer-based supports are truly effective at improving student learning and student success in math. However, there may have been other factors which limited the ability of Round 1 schools to significantly impact the five indicators of success identified by Achieving the Dream. For instance, most of the initiatives implemented by Round 1 colleges were small in scale (Rutschow et al., 2011). It is also possible that Round 1 schools experienced an influx of students who were significantly underprepared compared to the baseline cohort of students. Finally, none of the strategies discussed above and utilized by Round 1 schools systemically shortened the actual number of semesters it takes students to complete a gateway course.

Although the Round 1 Achieving the Dream schools did not achieve the type of gains in student completion they had hoped for, Achieving the Dream served to propel community colleges to the forefront of the national conversation around the need to improve the academic achievement of all students but particularly low-income students and students of color. Moreover, Achieving the Dream underscored that the challenges associated with improving the academic achievement of all students are complicated and difficult to solve. Ultimately, Achieving the Dream laid the foundation for future initiatives focused on this important work.

Carnegie Math Pathways Initiative

Another attempt to reform developmental education has been the Carnegie Math Pathways initiative that started with support provided by the Carnegie Foundation for the Advancement of Teaching. The Carnegie Math Pathways network seeks to improve the success of all students by incorporating systemic changes based on research and practitioner knowledge (“Mission & Approach,” n.d.). To achieve this goal, the network devised two new pathways, Statway® and Quantway®. Quantway is a college-level math course typically taken by students enrolled in liberal arts programs like English or music and focuses on developing quantitatively literate students while Statway is a college-level math course typically taken by students majoring in nursing, psychology, or other social sciences. The goal of Statway is to provide students a foundational understanding of statistics and analysis to prepare individuals for occupations where they need to make decisions based on uncertain data (“Statway,” n.d.).

Quantway is actually a two-semester sequence comprised of Quantway 1 and Quantway 2. Quantway 1 is a developmental math course that focuses on developing students’ quantitative reasoning skills and typically uses a course in pre-algebra as the course prerequisite. Quantway 2 is the actual college-level math course which uses Quantway 1 as its prerequisite and is what ultimately satisfies the mathematics requirement for liberal arts majors. In a similar vein, Statway is also a two-semester sequence where the first semester is a developmental math course (again using a course in pre-algebra as the prerequisite), designed to prepare students for the second semester course (Statway 2), which is the actual college-level course designed to satisfy students’ program requirements. Finally, it is important to note that Quantway and Statway may not be suitable options for students who desire to enter a

career in science, technology, engineering and mathematics or STEM. For STEM students, college algebra and/or precalculus are typically the first gateway or college-level mathematics courses that are completed.

One aspect which makes the Statway and Quantway Pathways unique is that they were specifically designed to provide students the opportunity to complete their developmental math requirement and college-level math requirement in two semesters (Norman, 2017), provided the student has either tested out of or completed pre-algebra. Another important aspect of both Statway and Quantway is that these courses do not require the use of intermediate algebra as their course prerequisite. This decision was made by the creators of Statway and Quantway since they did not believe that a background in intermediate algebra was needed for students to be successful in Statway and Quantway.

In contrast to many reform initiatives, the design and implementation of the Carnegie Math Pathways took a systems-level approach to the developmental mathematics crisis (“Instructional System,” n.d.) by focusing on five key drivers across the system: advancing quality teaching, network engagement, rapid analytics, relevant content, and productive persistence. The following paragraphs will briefly examine each key driver.

Advancing quality teaching is a key aspect of the Pathways. To ensure quality teaching the Pathways provide support to faculty new to teaching Quantway and Statway in a number of ways. For instance, experienced Statway and Quantway faculty are paired with new faculty to provide advice, teaching tips, and to serve as mentors. In addition, there are online activities and resources available to faculty new to Pathways and regional and national meetings are

hosted on a regular basis to provide intensive training and opportunities to network with other Pathways faculty (“Instructional System,” n.d.).

Network engagement is another key aspect of the Pathways. As mentioned above, a variety of regional and national events provide opportunities for Pathways faculty to connect with mathematics educators from across the country. These opportunities for Pathways faculty, administrators, and institutional researchers to network are intentional and, in fact, form the basis for what Carnegie refers to as a “Networked Improvement Community” or NIC (“Instructional System,” n.d.). As part of the NIC, administrators, faculty, and institutional researchers, design, implement, and improve innovative ways to address the needs of developmental math students (“Instructional System,” n.d.). This feedback combined with assessment data provided by institutional researchers is shared with the NIC and supports the continuous improvement of the materials used in Statway and Quantway. Finally, in order to ensure a two-way flow of information between members of the NIC and Pathways leadership at Carnegie, administrators at Pathways institutions participate in regular conference calls to provide updates on the status of implementing Pathways at their respective institutions. This is a great way for more advanced Pathways institutions to share lessons learned with institutions new to this model. It also allows Carnegie to inform members about upcoming curriculum changes and professional development opportunities for both faculty and administrators.

A complex and national reform initiative like the Pathways could not exist without high-quality data analytics. As part of the Pathways, NIC members receive regular updates about the performance of their respective students as well as the performance of students across the NIC as a whole (“Instructional System,” n.d.). Moreover, since all Quantway and Statway students

utilize common curricula, homework assignments and tests, the validity of the data is improved. In addition, the use of common summative assessments allows the NIC to more easily identify variation in the performance of students which may, in turn, call for additional research to understand the cause of the variation (“Instructional System,” n.d.).

The curricula in Quantway and Statway was specifically designed to be relevant to students by focusing on applications of mathematics and statistics that students will use in their everyday lives (“Instructional System,” n.d.). Rather than focusing on algebraic concepts that students might only use in a course such as college algebra, Quantway and Statway delve into practical problems like car loan payments, probability, or voting principles. By focusing on real-world problems that students may encounter in life or in the workplace, Quantway and Statway students are engaged and interested in learning (“Instructional System,” n.d.). Students who are engaged in learning are also more likely to take responsibility for their own learning.

Perhaps one of the most innovative aspects of the Pathways, and one that sets it apart from other initiatives, is that this model strives to systematically address “student beliefs about themselves as mathematical learners and doers” (“Productive Persistence,” n.d., para 2). Why is it that some students seem to put forth more effort to succeed than other students? Successful students recognize the importance of completing assignments on time, seek out assistance from their teachers or peers when needed, and consistently strive to do their best work. In contrast, unsuccessful students are often inefficient when it comes to completing assignments, are unable to consistently produce high quality work, and infrequently seek out assistance from teachers or peers. To help students stay on the path to successfully complete their math course, the Pathways approach strives to equip students with the tools and

strategies needed to overcome challenges (“Productive Persistence,” n.d.). In essence, the Pathways seek to enhance or improve students’ “grit” or will to succeed. The Carnegie Math Pathways refers to this strategy as “productive persistence” and defines it as the “package of skills and tenacity that students need to succeed in an academic setting” (“Instructional System,” n.d., para. 6). Few, if any, developmental mathematics reform initiatives have ever attempted such an undertaking on such a large scale.

The performance of both Quantway and Statway is well documented. Since the launch of both Pathways in the 2011 –12 academic year, student enrollment has grown from 1,551 at 29 institutions to 6,220 students at 36 institutions in the 2015 –16 academic year (Hoang, Huang, Sulcer, & Suleyman, 2017). Student completion of the Pathways has also been impressive. For instance, of the 7,628 students from all cohorts who attempted Statway, 3,875 successfully completed the full pathway and thus completed a college-level course in statistics in two semesters or less which equates to a 51 percent success rate for both two- and four-year students, with two-year students posting an impressive 49 percent success rate (Hoang et al., 2017). The overall success of all cohorts of Quantway students was also impressive with Quantway 1 students achieving an average course success rate of 59 percent over a five-year period and Quantway 2 students posting an average course success rate of 65 percent over a four-year period (Hoang et al., 2017).

Through the creation of an alternative pathway that is largely independent of both beginning and intermediate algebra, data shows that the Carnegie Pathways allow more students to complete college-level courses in both quantitative reasoning (QR) and introductory

statistics (IS). These results are consistent with Carnegie’s stated goal of supporting the success of all students (“Mission & Approach,” n.d.).

In order to fully implement Pathways in Ohio, the Ohio Department of Higher Education (ODHE) revised its definition of what it means for a math course to be considered college-level. According to ODHE, a college-level mathematics course must either broaden or extend student learning (“Rethinking postsecondary mathematics,” 2014). This revised definition of college-level mathematics combined with removal of Intermediate Algebra as the only acceptable prerequisite to college-level mathematics courses has permitted colleges in Ohio to implement the Pathways at their discretion.

Completion by Design and the Guided Pathways Movement

Two other initiatives which have had a significant impact on developmental education are Completion by Design (CBD) and the Guided Pathways movement. CBD was a five-year initiative sponsored by the Bill & Melinda Gates Foundation that provided funding to a cadre of community colleges from Florida, North Carolina, and Ohio to increase the completion rates of community college students by developing coherent pathways of study (Chaplot, Rassen, Jenkins, & Johnstone, 2013). A key document which arose out of the work of the cadres was the Loss/Momentum Framework. “This framework supports educators in designing every step of the student’s pathways with the end goal in mind—completion” (“Loss/momentum framework,” n.d., para1).

There are four phases of the Loss/Momentum Framework, namely, connection, entry, progress, and completion (“Loss/momentum framework,” n.d.). Given the complicated nature

of higher education, it is difficult to categorize students' educational experience into four discrete buckets. For this reason, there often is some degree of overlap between each of the four phases of the Loss/Momentum Framework.

According to the Completion by Design website, *connection* is defined as the period in which a student first expresses interest in attending college to the point at which the student applies to college ("Loss/momentum framework," n.d.). Given the large number of both two- and four-year institutions located throughout the United States competing for students' attention, the connection phase is an exciting time in student's life. However, it can also be an overwhelming experience for many students since the application process at many colleges can be extremely complicated. Households where one or both parents are college graduates likely have an advantage over households of potential first-generation college students since the former (1) recognize the importance of and have experience with college admission tests like the Suite of Assessments (SAT), (2) recognize the importance of completing the Free Application for Federal Student Aid (FAFSA) form, and (3) leverage both local scholarships (such as those offered by businesses in the local community) and scholarships offered by their preferred college or university to reduce the cost of higher education. Recognizing that applying to college is a complicated process, many two- and four-year institutions have greatly increased the level of support provided to students during the connection phase such as providing "Getting Ready for College" workshops where students and parents may receive a variety of services such as assistance completing the FAFSA, how to apply to the institution, and instructions on how to prepare for placement exams.

Entry is defined as the time from which the student is enrolled at an institution through completion of his or her first college-level or gateway course (“Loss/momentum framework,” n.d.). Clearly, the entry phase is a critical moment in a student’s educational journey since so many students fail to complete their developmental coursework. So, Completion by Design and Achieving the Dream schools were wise to broaden their focus on student completion beyond that of developmental education to include “revisiting” both academic advising and placement test strategies (“Entry,” n.d.) to increase the number of students who successfully complete this phase and subsequently enter the next phase.

Progress is the period in which a student first enters his or her major to the point at which the student has completed at least 75 percent of the courses in the program of study (“Progress,” n.d.). This is a critical milestone in the student’s academic journey since by this phase, he or she has likely completed any required developmental coursework and are now taking either general education courses (psychology, sociology, etc.), courses in his or her major, and/or college-level coursework in mathematics. Factors which can either slow or extend the time to completion in this phase would include major disruptions in the lives of students and the simple fact that many community college students can only attend college on a part-time basis study (“Progress,” n.d.). To combat these challenges, many community colleges have reduced the number of credit hours in their associate degrees to between 60 – 65 credit hours or deliver their programs in a flexible manner like a hybrid modality (which combines both online and face to face to class sessions) so that students can complete their program of study as quickly as possible.

Finally, *completion* is defined as the point at which a student completes his or her desired program of study (“Completion,” n.d.). It is in this final phase that community colleges assess the extent to which their strategies yield higher levels of student completion in less time, while at the same time reducing the number of students who either transfer without a credential or leave the institution with the bulk of their graduation requirements completed, save for their required college-level mathematics course (“Completion,” n.d.). Although graduation and commencement ceremonies are typically the climax of the completion phase of the Loss/Momentum Framework, were it not for the work which occurs in the first three phases of the Framework many students would never even complete their program of study.

Ultimately, both Completion by Design and Achieving the Dream leveraged the Loss/Momentum Framework to guide the conversation surrounding student completion. However, these two initiatives were not alone in their efforts. CBD worked closely with national assistance partners such as the RP Group, Public Agenda and Columbia University’s Community College Research Center (CCRC) to guide cadre colleges on their journey. CCRC, in particular, played a key role in taking the work begun by CBD to the next level in what has come to be known as the Guided Pathways Movement (Chaplot, et al., 2013).

According to Bailey, Jaggars & Jenkins (2015) when students at community colleges are selecting a major, they can choose from an entire “menu” of courses, programs, and support services which are often disconnected from each other. The sheer number of certificates and degrees available to students to select from combined with policies on placement tests, financial aid policies, enrollment procedures, utilizing academic advising services, etc., can have a negative impact on student completion because of the complexity associated with these

policies and procedures. To improve student completion, many 2- and 4-year institutions have completely redesigned their entire approach to student services. A guided pathway “presents courses in the context of highly structured, educationally coherent program maps that align with students’ goals for careers and further education” (Bailey, Jaggars & Jenkins, 2015, para. 5). Ultimately, guided pathways have the potential to streamline the “college experience” leading to improved student completion.

Jenkins and Cho (2014) highlight that there are three key features of guided pathways, namely clear maps to student’s end goals, on-ramps to programs of study, and strong academic advising. Since it is not uncommon for community colleges to offer as many as 50 different certificate and associate degree programs, it is imperative that community colleges create program maps for each certificate and associate degree. These maps lay out the ideal pathway for each program from start to finish. Moreover, the pathways need to have clear “on-ramps” so that prospective students understand the potential career fields, transfer opportunities, and earning potential which await them once they complete their intended program of study (Jenkins & Cho, 2014). Finally, academic advisors need access to tools which provide them with up-to-date information as to how their students are performing in class, they need the ability to quickly and easily contact their students, and the ability to easily schedule appointments with their students on days/times convenient for the students.

Ultimately, both Completion by Design and the Guided Pathways model have had a significant impact on reforming developmental education by encouraging educators to develop strategies which accelerate student completion of college-level courses in English and

mathematics as part of their overarching goal of increasing the number of students obtaining a post-secondary credential.

Student Progression Through Developmental Education

A longitudinal study of nearly 13,000 students enrolled at public two-year colleges in Ohio found that students enrolled in developmental English and math courses performed no worse (completed an associate degree or transferred to a four-year college) than similar students who did not enroll in developmental courses after accounting for differences in background demographics (Bettinger & Long, 2005). Nevertheless, Bettinger and Long (2005) indicate that remediation in math appeared to improve student outcomes. Finally, Bettinger & Long highlight the fact that it is not clear whether remediated students outperform similar students not required to take developmental classes. In contrast, a study by Attewell et al. (2006) found that after controlling for high school preparation and academic skills, students who take two or more remedial mathematics courses at two-year colleges were slightly less likely to graduate compared to non-remedial students.

In order to better understand student progression through developmental course sequences among students actually referred to developmental education, the Lumina Foundation for Education commissioned a study of the Achieving the Dream initiative. The study, conducted by Bailey et al. (2009), used student record information collected from more than 250,000 students who were impacted by the initiative. The Achieving the Dream (ATD) data set included a wealth of information such as student demographics as well as enrollment and completion data for both remedial and college-level courses.

Based on an analysis of the ATD dataset, 59 percent of students in the sample were referred to developmental math, 35 percent of which were referred to two or more levels below college-level math, and ultimately only 33 percent of students in the sample actually completed their required developmental math courses (Bailey et al., 2010). Bailey et al. add that 11 percent of students enrolled in developmental math and 8 percent of students enrolled in developmental reading successfully completed one or more developmental courses but then failed to enroll in the next course in the sequence (2010). Moreover,

if one combines the number of students who never enrolled with those who exited between courses, more students did not complete their sequence because they did not enroll in the first or a subsequent course than because they failed a course (Bailey et al., 2010, p. 10).

Ultimately, there could be many reasons as to why a student either never enrolled in their developmental course or did not enroll in the next course in their sequence of developmental courses. Nevertheless, the aforementioned examples underscore the importance of making the path to and through gateway mathematics courses as short as possible since time is the enemy of completion. The following pages describe a strategy which may increase the number of developmental students who complete a college-level math course in two academic semesters.

COREQUISITE REMEDIATION

What is Corequisite Remediation?

Like many community colleges, the research site relies on a placement test, namely Accuplacer, to assess whether students are “college-ready.” Students who are deemed college-

ready based on earning a satisfactory score on the placement test or some other metric, begin their college career taking college-level mathematics or English courses while those students not deemed college-ready begin their college career by taking one or more developmental courses in math, English, and/or reading. To illustrate, suppose a student who wants to major in chemistry takes a placement test and places two levels below his or her required gateway course; usually, College Algebra. Such a student would typically enroll in a course such as beginning algebra. Once the student successfully completes beginning algebra (with a grade of “C” or better), the student would then enroll in a second course, such as intermediate algebra. After successfully completing this course, the student would then be permitted to enroll in College Algebra. The type of remediation just described is known as Prerequisite Remediation. Most developmental course sequences offered at two- and four-year institutions utilize prerequisite remediation. With prerequisite remediation, students are required to take each developmental course in a sequential manner. After completing all required developmental coursework, which could take as long as two or three semesters, students are permitted to take their gateway course.

Corequisite remediation stands in stark contrast to prerequisite remediation. As was mentioned earlier, corequisite remediation is a strategy which reduces the amount of time it takes for students to complete their gateway English or mathematics course by allowing them to directly enroll in their gateway course while taking a developmental English, reading, or math course at the same time (“Corequisite remediation: Spanning,” n.d.). Corequisite remediation provides an alternative to the manner in which prerequisites are typically handled.

To illustrate, suppose a student's program of study requires him or her to take college algebra at the research site. Assuming the student had either tested out of or completed pre-algebra with a grade of "C" or better, the student would first take beginning algebra. Assuming the student completed this course with a grade of "C" or better, the student could then enroll in a three-semester hour college algebra course and a one-semester hour developmental math (Booster) course. These two courses together would total six contact hours per week spread over a 16-week semester with the Booster course containing the topics from intermediate algebra critical to success in college algebra and delivering them in a "just-in-time" manner.

In this way, students enrolled in the Booster course receive the academic support they need while also taking the college-level course. Thus, students who have tested out of pre-algebra (or already have credit for the course), have the potential to complete college algebra in two semesters and students who have tested out of beginning algebra (or already have credit for the course) have the potential to complete college algebra in one semester. In a similar manner, corequisite remediation can accelerate student completion of gateway mathematics courses like Quantitative Literacy and Introductory Statistics.

Corequisite remediation immediately engages underprepared students in college-level mathematics courses while providing them needed academic support in a just-in-time basis. It does not eliminate the academic support needed by underprepared students (Vandal, 2014). Instead, the support needed by underprepared students that would typically be delivered in the prerequisite course is instead delivered via a developmental course that students take at the same time as the college-level course. Moreover, the developmental course is taught using a variety of collaborative learning techniques, making for a highly engaging and interactive

learning environment. In addition, students in the developmental course are taught study-skills, time management techniques, tips on how to avoid math anxiety, and other strategies designed to support student success and learning. Additionally, corequisite remediation provides students the opportunity to complete their gateway course in less time since they are taking both the gateway course and a developmental course at the same time. The following paragraphs will discuss the impact of corequisite remediation on student completion in other states which have implemented the model.

The Impact of Corequisite Remediation

According to Harris (2017), about 60 percent of students in the Tennessee system arrive at college campuses needing remediation. Harris goes on to add that prior to implementing corequisite remediation, about 12 percent of remedial students completed a gateway math course in their first year but after implementing corequisite remediation in math that number increased to 51 percent (2017).

Texas is another state that has implemented corequisite remediation. At Texas State University-San Marcos, the FOCUS program allows students whose math placement scores are just below college level to enroll in either college algebra or college algebra with statistics and a remedial math course (Complete College America, n.d.). Additionally, Complete College America (n.d.) notes that remedial math students who participated in FOCUS pilot programs offered in Summer 2008 and Summer 2010 successfully completed college algebra with a grade of "C" or higher during their first semester of enrollment at the rate of 88 percent and 74 percent respectively.

In 2012, nearly 500 remedial college students participated in the FOCUS program (Complete College America, n.d.). This time, according to Complete College America (n.d.), 61 percent of FOCUS students completed the gateway course with a grade of “C” or higher, compared to 52 percent of college-ready students. In July 2017, corequisite remediation was signed into law as the required model for students in need of developmental education courses by Texas Governor Greg Abbott (Smith, 2017).

SUMMARY

A review of the literature highlights the fact that large numbers of students are placed in long sequences of developmental courses as the primary means of preparing them for college-level coursework in English and mathematics, and that students of color such as African-American students, Latinos, students from low socio-economic backgrounds, and Pell recipients are disproportionately assigned to developmental courses. Although completion of these developmental course sequences allows some students to enroll in and complete their required gateway courses, large numbers of developmental students fail to enroll in their next developmental course, even if they earned a passing grade in the course prerequisite. Hence, it appears that large numbers of developmental students never get the opportunity to enroll in their required gateway mathematics course. As a result, developmental education students, which would include students from underrepresented populations, appear to have lower completion rates of gateway mathematics courses and lower college attainment rates compared to the general population of college-going students. The numerous initiatives designed to improve the completion rates of developmental students, particularly at

community colleges, suggests that institutions of higher education recognize that developmental education is failing large numbers of students each year.

A key reason for the failure of developmental education is the fact that prerequisite remediation requires students to enroll in long sequences of developmental coursework that take students years to complete. In contrast to prerequisite remediation, research indicates that acceleration strategies like corequisite remediation allow students to complete college-level coursework, such as college algebra, in as little as two semesters while providing students the academic support they need to succeed. Despite this promising research, it is critically important to ensure that a strategy designed to improve student completion of gateway mathematics courses, such as corequisite remediation, does not negatively impact the academic achievement of students. Chapter Three will discuss the how the study was implemented.

CHAPTER THREE: METHDOLOGY

PURPOSE OF THE STUDY

The purpose of this study was to examine the impact of a corequisite remediation model for mathematics, in contrast to the traditional prerequisite remediation model, at a large, urban, community college located in the downtown business district of the sixth largest city in the State of Ohio. In particular, does the use of corequisite remediation, in contrast to prerequisite remediation, (1) increase the number of students successfully completing selected gateway mathematics courses and, (2) improve student achievement, as measured by the final course grade, in selected gateway mathematics courses? The remainder of this chapter will describe the following: the research questions and related hypotheses, the research site, participants in the study, the design of the study, data collection methods, data analysis techniques, potential threats to reliability and validity, and limitations of this study.

RESEARCH QUESTIONS

The following research questions in this quasi-experimental design guided this study:

1. Research Question 1 (RQ1)

Does corequisite remediation, as compared to prerequisite remediation, increase the number of students successfully completing selected gateway mathematics courses in the 2017 Spring Semester compared to the 2016 Spring Semester with a grade of “D” or better?

2. Research Question 2 (RQ2)

Was there a significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to the proportion of students who successfully completed the same course with a grade of “D” or better via prerequisite remediation?

Hypotheses for RQ2

Null Hypothesis

H_0 : For students enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better. Hence, $H_0: u_1 = u_2$.

Alternative Hypothesis

H_1 : For students enrolled in selected gateway mathematics courses, there was a significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better. Hence, $H_1: u_1 \neq u_2$.

3. Research Question 3 (RQ3)

For students flagged as a Performance Based Funding Eligible Minority (PBFEM) students enrolled in selected gateway mathematics courses, was there a significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better via corequisite remediation (Booster students) compared to PBFEM students who successfully completed the same course with a grade of “D” or better via prerequisite remediation (Non-booster students)?

Hypotheses for RQ3

Null Hypothesis

H_0 : For students flagged as a PBFEM who were enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better via corequisite remediation (Booster students) compared to the proportion of PBFEM students who successfully completed the same course with a grade of “D” or better via prerequisite remediation (Non-booster students). Hence, for $H_0: u_1 = u_2$.

Alternative Hypothesis

H₁: For students flagged as a PBFEM who were enrolled in selected gateway mathematics courses, there was a significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better via corequisite remediation (Booster students) compared to the proportion of PBFEM students who successfully completed the same course with a grade of “D” or better via prerequisite remediation (Non-booster students). Hence, for H₁: $u_1 \neq u_2$.

4. Research Question 4 (RQ4)

For students enrolled in selected gateway mathematics courses, was there a significant difference in the proportion of Non-Performance Based Funding Eligible Minority (Non-PBFEM) students who successfully completed the course via corequisite remediation (Booster students) with a grade of “D” or better compared to Non-Performance Based Funding Eligible Minority (Non-PBFEM) students who successfully completed the course via prerequisite remediation (Non-booster students) with a grade of “D” or better?

Hypotheses for RQ4

Null Hypothesis

H₀: For students flagged as a Non-PBFEM enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of Non-PBFEM students who successfully completed the course via corequisite remediation (Booster students) with a grade of “D” or better compared to Non-PBFEM students who successfully completed the course via prerequisite remediation (Non-booster students) with a grade of “D” or better. Hence, for H₀: $u_1 = u_2$.

Alternative Hypothesis

H₁: For students flagged as a Non-PBFEM enrolled in selected gateway mathematics courses, there was a significant difference in the proportion of Non-PBFEM students who successfully completed the course via corequisite remediation (Booster students) with a grade of “D” or better compared to Non-PBFEM students who successfully completed the course via prerequisite remediation (Non-booster students) with a grade of “D” or better. Hence, for H₁: $u_1 \neq u_2$.

5. Research Question 5 (RQ5)

For students enrolled in selected gateway mathematics courses who were flagged as ever being eligible to receive a Pell grant, was there a significant difference in the

proportion of these students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students)?

Hypotheses for RQ5

Null Hypothesis

H_0 : For students enrolled in selected gateway mathematics courses who were flagged as ever being eligible to receive a Pell grant, there was no significant difference in the proportion of these students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to those students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for H_0 : $u_1 = u_2$.

Alternative Hypothesis

H_1 : For students enrolled in selected gateway mathematics courses who were flagged as ever being eligible to receive a Pell grant, there was a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for H_1 : $u_1 \neq u_2$.

6. Research Question 6 (RQ6)

For students enrolled in selected gateway mathematics courses who have not been flagged as ever being eligible to receive a Pell grant, was there a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students)?

Hypotheses for RQ6

Null Hypothesis

H_0 : For students enrolled in selected gateway mathematics courses who have not been flagged as ever being eligible to receive a Pell grant, there was no significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to students who successfully completed the same course via

prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for $H_0: u_1 = u_2$.

Alternative Hypothesis

H_1 : For students enrolled in selected gateway mathematics courses who have not been flagged as ever being eligible to receive a Pell grant, there was a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for $H_1: u_1 \neq u_2$.

7. Research Question 7 (RQ7)

For students enrolled in selected gateway mathematics courses, does the type of remediation (corequisite remediation versus prerequisite remediation) predict academic achievement in selected gateway mathematics courses, as measured by the Final Course Grade (FCG), while controlling for the student’s Grade Point Average (GPA) and the student’s Initial Math Placement Level (IMPL)?

RESEARCH SITE

The research for this study was conducted at a large, urban community college located in the downtown business district of the sixth largest city in the State of Ohio. The college serves more than 30,000 unique individuals each calendar year, spread across five separate locations and offering more than 220 certificate and associate degree programs. As a publicly funded community college, the college utilizes an open enrollment admission’s policy. All students who desire to enter an academic program of study are required to take placement tests that assess students’ readiness in English, mathematics, and reading. Based on the results of these placement tests and specific course and/or program-level requirements, a student may be required to complete developmental coursework in English, mathematics, and/or reading before being permitted to enroll in college-level, credit-bearing courses.

PARTICIPANTS IN THE STUDY

This study used institutional-level data of students enrolled in selected gateway mathematics courses or a gateway mathematics course “co-requisitely” paired with a developmental mathematics course at the research site. In particular, the subjects of the study were students enrolled in face-to-face sections of Quantitative Literacy (MAT 1445), Quantitative Literacy paired with a Quantitative Literacy Booster course (MAT 0445), College Algebra (MAT 1470), College Algebra (MAT 1470) paired with a College Algebra Booster (MAT 0470) course, Introductory Statistics (MAT 1450), or Introductory Statistics (MAT 1450) paired with an Introductory Statistics Booster (MAT 0450) course. Whenever a college-level or gateway course was co-requisitely paired with a developmental course, the same instructor taught both course sections. The gateway course sections and the corequisite or booster course sections were taught during the 2017 Spring Semester by either adjunct or full-time mathematics faculty. As an open enrollment institution, participants self-selected whether they enrolled in a gateway course or a gateway course paired with a corequisite course, based on whether they satisfied the course prerequisite. Some of the most common enrollment pathways are described below:

1. Enrolled in Quantitative Literacy (MAT 1445) via (1) prerequisite remediation based on satisfactory completion of Beginning Algebra (MAT 1270), or (2) obtaining a sufficiently high score on a math placement exam that essentially allowed a student to “test out” of Beginning Algebra.
2. Enrolled in both Quantitative Literacy (MAT 1445) and Quantitative Literacy Booster (MAT 0445) via (1) corequisite remediation based on satisfactory completion of Pre-Algebra (DEV 028), or (2) by obtaining a sufficiently high score on a math placement exam that allowed a student to test out of Pre-Algebra.

3. Enrolled in Introductory Statistics (MAT 1450) via (1) prerequisite remediation based on satisfactory completion of Intermediate Algebra (MAT 1365 or 1370) or (2) obtaining a sufficiently high score on a math placement exam that allowed a student to test out of Intermediate Algebra.
4. Enrolled in Introductory Statistics and Introductory Statistics Booster (MAT 0450) via (1) corequisite remediation based on satisfactory completion of Beginning Algebra or (2) obtaining a sufficiently high score on a math placement exam that allowed a student to test out of Beginning Algebra.
5. Enrolled in College Algebra (MAT 1470) via (1) prerequisite remediation based on satisfactory completion of Intermediate Algebra (MAT 1365 or 1370), or (2) obtaining a sufficiently high score on a math placement exam that allowed a student to test out of Intermediate Algebra.
6. Enrolled in both College Algebra and College Algebra Booster (MAT 0470) via (1) corequisite remediation based on satisfactory completion of Beginning Algebra or (2) by obtaining a sufficiently high score on a math placement exam that allowed a student to test out of Beginning Algebra.

It should be noted that students may have been able to enroll in the selected gateway mathematics courses based on (1) completion of one or more courses prerequisite to a gateway course, (2) testing out of one or more prerequisite courses by taking a mathematics placement test, or (3) some combination of items (1) and (2). No special consideration was given to the pathway or sequence of courses completed by students in this study prior to their enrollment in one of the selected gateway math courses in the 2017 Spring Semester.

However, students who tested into a gateway mathematics course in the 2017 Spring Semester were excluded from any analysis which examined the student's academic achievement, since these students did not experience either corequisite remediation or prerequisite remediation. Additionally, students who enroll in a gateway mathematics course co-requisitely paired with a developmental mathematics course will often be referred to as Booster students, while

students who enrolled in a gateway mathematics course via prerequisite remediation will often be referred to as Non-booster students.

DESIGN OF THE STUDY

The gateway mathematics courses included in this study were Quantitative Literacy (MAT 1445), Introductory Statistics (MAT 1450), and College Algebra (MAT 1470). In most cases, each gateway course section included in the study was paired with a booster course section. Moreover, the same instructor was used to teach the gateway section and the booster course. Students who enrolled in a gateway course section paired with a booster section were considered the treatment group since they were taking a college-level mathematics course paired with a developmental mathematics course. The control group, in contrast, was comprised of students who enrolled in one of the selected college-level mathematics courses via prerequisite remediation and were therefore not enrolled in a booster section.

It should be mentioned that one section of Introductory Statistics (MAT 1450) was offered at a satellite location operated by the college and taught by a full-time faculty member. This location did not have any students taking the college-level class paired with a developmental course and thus explains why there was one fewer section of the Introductory Statistics Booster than Introductory Statistics. In addition, the 20 different sections of College Algebra (MAT1470) were taught by 16 different instructors, 13 of which were considered full-time faculty. Finally, there were 13 different sections of Quantitative Literacy (MAT 1445) that were paired with an equal number of sections of Quantitative Literacy Booster. These 13 sections were taught by 11 different instructors; 10 of whom were full-time faculty.

Students were permitted to self-select which section they enrolled in based on whether they satisfied the course prerequisite. Gateway mathematics course sections and booster sections utilized in this study were offered at a variety of days and times throughout the 16-week semester. However, in every case, students always attended the booster section before attending the gateway section. To illustrate, if a section of College Algebra Booster (MAT 0470), was offered on Monday, Wednesday, and Friday from 8:00 a.m. to 8:50 a.m., then it was paired with a section of College Algebra (MAT 1470) that was offered on Monday, Wednesday, and Friday from 9:00 a.m. to 9:50 a.m. A similar pattern was followed for courses offered in a two-day per week format.

Faculty teaching the gateway courses included in this study were permitted to utilize whatever method of instruction they desired. In most cases, lecture was the primary teaching method used. However, the use of web-based, instructional tools such as MyMathLab for Quantitative Reasoning, Macmillan's LaunchPad, and Pearson's MyLabs, were required in Quantitative Literacy, Introductory Statistics, and College Algebra, respectively. To ensure a minimum level of uniformity across all sections, it is common at this institution to provide course instructors with a master course shell for both gateway and developmental sections. The master course shell was delivered via the institution's Learning Management System (LMS). The LMS used at this institution is known as eLearn and is a derivative of the well-known LMS known as Desire to Learn. The eLearn shells were prepopulated with a variety of learning aids such as video lectures, "paper and pencil" worksheets, and test-taking strategies.

Faculty teaching the booster courses were also permitted to utilize whatever method of instruction they desired with the understanding that the booster sections were meant to be

taught in a highly engaging and collaborative manner. Although the use of lecturing was permitted in the booster sections, faculty were strongly discouraged from devoting a significant amount of class time to lecturing. Instead, faculty were encouraged to utilize short, “mini-lectures” to reinforce students’ understanding of the key prerequisite concepts needed to support their understanding of the college-level concepts that would subsequently be discussed in the gateway class. After the mini-lectures were concluded, students were then placed in groups of two or three and spent the remaining class time practicing the concepts that were just discussed. The use of Pearson’s MyLabs was also a required component in the College Algebra Booster sections.

Ultimately, students’ course grades in the booster sections were heavily weighted towards completion of assignments, either in-class or outside of class. For the Quantitative Literacy Booster, 100 percent of the students’ final course grade was based on in-class participation. For the Introductory Statistics Booster, the students’ final course grades were based on the following: 30 percent from in-class group work and 70 percent from homework sheets completed outside of class. Final course grades for students in the College Algebra Booster sections were based on the following: 30 percent based on completion of pre-lecture videos and problems in MyLabsPlus, 40 percent from homework sheets completed in class, and 30 percent from in-class proctored exams. Due to the rigorous nature of College Algebra, the team of faculty who developed the curriculum for the College Algebra Booster sections decided to utilize in-class, proctored exams in contrast to the booster courses developed for both Quantitative Literacy and Introductory Statistics.

In this study, student achievement was measured by the final course grade assigned by the instructor of record in the gateway course. In general, instructors teaching the courses used in this study were permitted to use their professional expertise and judgement to assess students. However, all faculty were expected to abide by the following departmental guidelines when determining the final course grade in the college-level or gateway courses:

- All chapter exams were to be administered in-class, proctored, and count 60 percent of the student's course grade.
- A comprehensive final exam must be administered and count for 20 percent of the student's course grade.
- Assignments completed outside of the classroom such as laboratory exercises (MAT 1450 only), paper and pencil homework, quizzes, and/or online or web-based homework must count 20 percent of the student's course grade.

Once the student's final course grade was computed, the grading scale listed below was used in both the gateway courses and the developmental courses to convert the numerical course grade to a letter grade.

Table 1: Letter Grade Scale

Letter Grade	Course Average
A	90 - 100
B	80 - 89
C	70 - 79
D	60 - 69
F	0 - 59

DATA COLLECTION METHODS

This study utilized a variety of institution-level data from the 2017 Spring Semester. Data used in this study was collected by the Research, Analytics, and Reporting (RAR) department at the institution and included the following: gender, a flag indicating whether the student was a Performance Based Funding Eligible Minority, birthdate, a flag indicating whether the student ever received a Pell grant at the institution, the first mathematics course the student enrolled in at the institution, the term in which the student first enrolled in a mathematics course at the institution, the letter grade the student received in the first mathematics course the student enrolled in at the institution, the most recent mathematics course the student enrolled in at the institution prior to the 2017 Spring Semester, the term in which the student most recently enrolled in a mathematics course at the institution prior to the 2017 Spring Semester, the letter grade the student received in the mathematics course the student most recently enrolled in at the institution prior to the 2017 Spring Semester, the mathematics course(s) the student enrolled in at the institution in the 2017 Spring Semester, the letter grade(s) the student received in the mathematics course(s) the student enrolled in at the institution in the 2017 Spring Semester, the total number of credit hours accumulated at the institution prior to the start of the 2017 Spring Semester, the student's cumulative grade point average effective 1 January 2017, and the student's mathematics placement test scores. Finally, each student's institutional identification number was replaced with an anonymized student identification number so that the researcher could not identify the students.

In addition to data analyzed from the 2017 Spring Semester, the researcher also analyzed institution-level data of students enrolled in selected gateway mathematics courses

(MAT 1440/1445, 1450, and 1470) and developmental courses (MAT 1270, 1355, 1365, and 1370) during the 2016 Spring Semester. This data was also collected by the Research, Analytics, and Reporting (RAR) department at the institution.

DATA ANALYSIS TECHNIQUES

Research Question 1 (RQ1) in this study will be examined using descriptive statistics. This research question seeks to broadly assess the impact of corequisite remediation by comparing the number of students who successfully completed selected gateway mathematics courses with a grade of “D” or better in the 2016 Spring Semester to that of the 2017 Spring Semester. Research Questions 2 through 6 (RQ2 – RQ6) were analyzed using the Chi-Square test of Independence, at the .05 level of significance, to determine the existence of a significant difference in student achievement while Research Question 7 (RQ7) was analyzed using logistic regression.

As was noted earlier, the final course grades submitted by the instructors were letter grades and the possible grades submitted included the following: A, B, C, D, F, I, W, and/or Z. Students were awarded a grade of “W” if they enrolled in and participated in class but “withdrew with record” according to the published policies of the institution. Students who earned a grade of W were included in the statistical analyses so that the impact of earning a grade of W would be considered in the analyses. In contrast, students who were assigned grades of “I” or “Z” were excluded from the study. Finally, before performing any statistical analyses on the final course grades, the letter grades were converted to discrete, numerical

values, based on the table below, where a value of “1” denotes success and a value of “0” denotes non-success.

Table 2: Converting a letter grade to its numerical equivalent.

Final Course Grade	Numerical Equivalent
A, B, C, or D	1
F or W	0

REDUCING THREATS TO RELIABILITY AND VALIDITY

As noted by Vogt (2007), performing invalid research or utilizing unreliable approaches to research has little value. In this study, threats to reliability have been minimized through the use of clear operational definitions of variables and by the research design. Regarding validity, Vogt (2007) adds that “the chief threats to validity that arise in applied research are self-selection effects, volunteer effects, attrition, history effects, maturation effects, and communication among subjects” (p. 122). The following pages will provide a brief summary of the extent to which any of the aforementioned threats to validity impact this study.

According to Vogt (2007), a quasi-experimental design is an experiment or research procedure that is like a true experiment but either prohibits or severely restricts the ability of the researcher to incorporate random assignment techniques. In this study, students had the ability to self-select whether they were going to enroll in selected gateway mathematics courses via corequisite remediation or continue to participate in the traditional model of prerequisite remediation. Thus, given that the researcher was unable to randomly assign students to a given type of remediation, this research study fits the definition of a quasi-experimental design. As a result, self-selection effects pose a threat to the external validity of

this study and (1) reduces or eliminates the ability of the researcher to explain the occurrence of variance in the dependent variables, (2) makes it difficult for the results of this study to be replicated, and (3) limits the ability of the researcher to generalize the results of this study beyond the research site.

The impact of maturation effects as a threat to internal validity was minimized since the duration of the study was relatively short, one semester in length, and since the study utilized comparison (students who participated in prerequisite remediation) and treatment groups (students who participated in corequisite remediation). In general, the researcher assumes that participants in the comparison and treatment groups will generally develop in similar ways. Moreover, an analysis of the relative performance of both groups using demographic information will provide a better understanding of the inherent differences and/or similarities of the performance of the participants in each group. However, internal validity is threatened by the volunteer effect since the nature of research in higher education almost invariably requires a willingness for students to volunteer for a study (Vogt, 2007), regardless of whether the students were even aware that they were participating in a study.

The nature of community college students, combined with the long sequences of developmental coursework (which takes many community college students years to complete) inherent in prerequisite remediation, increases the likelihood that history effect and communication poses a threat to the internal validity of this study. Finally, attrition is also a threat to the internal validity of this study since the inherent acceleration associated with corequisite remediation of students through their developmental coursework may cause higher

rates of nonsuccess in course sections utilizing corequisite remediation compared to those sections using prerequisite remediation.

LIMITATIONS

This study used archival data from the college's student records system known as

Datatel. Key limitations of this study were as follows:

1. Students self-selected whether they enrolled in a gateway course utilizing corequisite remediation.
2. The results of this study relied heavily on the final course grades that were assigned by multiple faculty. Although the department which houses the courses upon which this study is based required faculty teaching the courses to use standardized assessment practices, the researcher has not verified the interrater reliability of these faculty.
3. For each corequisite pairing, the college-level course and the developmental level course was taught by the same faculty. There was one exception to this rule in that one section of Introductory Statistics (MAT 1450) was not paired with a section of Introductory Statistics Booster (MAT 0450), since all students enrolled in the section of Introductory Statistics either tested college-ready or had completed the course prerequisite.
4. Corequisite pairings were taught by either full-time faculty or adjunct faculty, subject to their availability. In particular, all course sections of Introductory Statistics and Introductory Statistics Booster were taught by full-time faculty while course sections of College Algebra, College Algebra Booster, Quantitative Literacy, and Quantitative Literacy Booster were taught by either full-time or adjunct faculty, with the majority of sections taught by full-time faculty.
5. In contrast to both MAT 1450 and MAT 1470, a departmental final exam was not utilized in sections of Quantitative Literacy (MAT 1445), as had been originally planned by the MAT 1445 faculty coordinator. This change was beyond the control of the researcher.

SUMMARY

As noted in the review of literature, a number of states have begun the wholesale implementation of corequisite remediation in both gateway English and mathematics courses since this approach is hailed as dramatically increasing the number of students who successfully complete gateway courses. Hence, one of the research questions included in this study seeks to first determine whether the number of students at the research site successfully completing selected gateway mathematics courses in 2017 have increased compared to 2016. The remaining research questions will then examine (1) whether there was a significant difference in the academic achievement of students who successfully completed selected gateway mathematics courses via corequisite remediation compared to prerequisite remediation and (2) if the type of remediation (corequisite compared to prerequisite) was predictive of the academic achievement of the students. The outcome of these research questions has the potential to influence whether institutions utilize corequisite remediation as a strategy to increase student completion of gateway mathematics courses.

CHAPTER FOUR: DATA ANALYSIS

INTRODUCTION

The purpose of this study was to examine the impact of implementing a corequisite remediation policy, in contrast to the traditional prerequisite remediation policy in selected gateway mathematics courses, namely, Quantitative Literacy (MAT 1445), Excursions in Mathematics (MAT 1440), Introductory Statistics (MAT 1450), and College Algebra (MAT 1470). In general, the overarching goals of implementing a corequisite remediation policy was to (1) increase the number of students successfully completing selected gateway mathematics courses and, (2) improve student achievement, as measured by the final course grade, in selected gateway mathematics courses.

Beginning in fiscal year 2015, Ohio fully implemented Performance Based Funding (PBF) at both two- and four-year institutions. As part of this plan, two-year colleges in the state will be funded as follows: 50 percent based on course completions, 25 percent based on Success Points (students earning 12 or 15 credit hours), and 25 percent based on students achieving Completion Milestones such as completing a 30-semester hour certificate, completing an associate degree, or transferring to a four-year university with 12 or more credit hours (Boudaris, 2014). Also beginning in FY 2015, Ohio's PBF metrics included three "access categories" for students who are considered either at-risk or from historically underrepresented populations; namely, adult, low-income, and minority (Boudaris, 2014). In

particular, adults age 25 and older at time of enrollment, low-income students who were ever Pell-eligible in their college career, and minority students (African American, American Indian, and/or Hispanic) were classified as at-risk (Boudaris, 2014), since enrollment of these students in college is traditionally underrepresented and they tend to have lower success rates in college. Institutions of higher learning in Ohio that implement strategies which positively impact the success of these students will have their efforts rewarded via the access categories in the state's PBF formula (Boudaris, 2014).

Pell Grants are a type of financial aid awarded by the federal government. Although there are a variety of factors that are used to determine whether a student may receive a Pell Grant, Pell funding is usually awarded to students whose families make less than \$50,000 annually ("Federal Grants", n.d.). At the research site, a PBFEM student was any student who self-identified his or her race/ethnicity as being either African American, American Indian, and/or Hispanic. Since the research site is located in an urban setting, it is critically important to assess the impact on the academic achievement of students from underrepresented populations when implementing a new policy like corequisite remediation and to be aware of any dramatic changes in enrollment patterns of these students as a result of a new policy.

The following pages will summarize the results of statistical analyses performed on the data. Research Question 1 (RQ1) will examine whether implementing a policy of corequisite remediation, compared to prerequisite remediation, increased the number of students who successfully completed selected gateway mathematics courses. For this research question, data collected from students enrolled in selected gateway mathematics courses during 2016 served as the control group, with data collected from students enrolled in selected gateway

mathematics courses during 2017 serving as the treatment group. The treatment applied was corequisite remediation, which was initially implemented at the research site in the 2017 Spring Semester. Descriptive statistics were then used to determine whether a policy of corequisite remediation increased the number of students successfully completing selected gateway mathematics courses with a grade of “D” or better. Research Question 2 (RQ2) focuses on the academic achievement of students by using bivariate statistics to determine whether there was a significant difference in the proportion of students who successfully completed selected gateway mathematics courses via corequisite remediation compared to prerequisite remediation. Research Questions 3 through 6 will use bivariate statistics to determine whether there was a significant difference in the academic achievement of underrepresented populations who completed selected gateway mathematics courses via corequisite remediation compared to prerequisite remediation. Finally, Research Question 7 (RQ7) will use logistic regression to determine whether the type of remediation (corequisite versus prerequisite) is predictive of student success while controlling for students’ cumulative grade point average and their initial mathematics placement level (IMPL).

RESEARCH QUESTION 1: FINDINGS AND ANALYSES

Research Question 1 (RQ1) sought to broadly examine the impact of corequisite remediation by using descriptive statistics to compare the number of students who completed selected gateway mathematics courses in the 2016 Spring Semester to the 2017 Spring Semester. In particular, RQ1 posed the following question:

Does corequisite remediation, as compared to prerequisite remediation, increase the number of students successfully completing selected gateway mathematics courses in

the 2017 Spring Semester compared to the 2016 Spring Semester with a grade of “D” or better?

Quantitative Literacy—MAT 1440/1445

As was discussed in Chapter Three, the primary liberal arts mathematics course offered at the research site in 2016 was then known as Excursions in Mathematics (MAT 1440). This course was designed to meet the program outcomes of students intending to transfer to a four-year university and major in programs such as psychology or history. Beginning in 2017, the research site began offering a new liberal arts mathematics course known as Quantitative Literacy (MAT 1445). Although the content of MAT 1445 was different compared to that of MAT 1440, the overarching goals of these two courses were the same; namely, to improve students’ decision-making ability based on quantitative information. As a result, the researcher has treated all data associated with these two courses as interchangeable.

During 2016 there were a total of 155 students enrolled in classroom sections of MAT 1440. In contrast, during 2017 there were a total of 204 students enrolled in classroom sections of Quantitative Literacy (MAT 1445). Thus, 31.6 percent more students were enrolled in MAT 1445 in 2017, compared to the equivalent course, MAT 1440, in 2016. It should be noted though that two distinct courses served as the course prerequisite to MAT 1440 in 2016, namely Beginning Algebra (MAT 1270) and Mathematical Reasoning (MAT 1340). Completion of either course with a grade of “C” or better allowed students to enroll in MAT 1440. Additionally, students were also permitted to enroll in MAT 1440 by obtaining a satisfactory score on a math placement test.

The combined enrollment in both MAT 1270 and MAT 1340 in 2016 was 1,094 students and 50.3 percent of those students successfully completed either course with a grade of “C” or better. In 2017, the course prerequisite to MAT 1445 was a grade of “C” or better in Beginning Algebra (MAT 1270), with 819 students enrolled in the course and 49.7 percent of those students successfully completing the course with a grade of “C” or better. One possible explanation for the higher enrollment MAT 1445 in 2017, compared to the enrollment in MAT 1440 in 2016, was that a significant portion of students who were eligible to enroll in Beginning Algebra may have instead elected to enroll in Quantitative Literacy (and its associated corequisite course, MAT 0445) due to the corequisite remediation policy.

In Table 3, the number of students who were flagged as ever being eligible to receive Pell funding (at any point up to and including the term under consideration) may be found in the “Pell Flag” row labeled “Yes” while students who were not flagged as ever being eligible to receive Pell funding may be found in the Pell Flag row labeled “No.” As noted in Table 3, there was a slight increase in the percentage of students enrolled in MAT 1445 in 2017 compared to MAT 1440 in 2016 that were flagged as ever being “Pell-eligible” at some point in their tenure at the research site. Table 3 also displays the relative frequencies and percentages of students based on the following classifications: “0” = Non-PBFEM, “1” = PBFEM, and “Missing” = No information was provided by the student. In 2017, there was an increase in the percentage of students enrolled in MAT 1445 that were flagged as a Performance Based Funding Eligible Minority, compared to MAT 1440 in 2016.

Table 3: Frequency distribution of enrollment in MAT 1440/MAT 1445 by PBFEM status and Pell Flag

MAT 1440/MAT 1445									
	PBFEM Status				Pell Flag	Pell Flag			
	2016/Spring MAT 1440		2017/Spring MAT 1445			2016/Spring MAT 1440		2017/Spring MAT 1445	
Label	Frequency	Percent	Frequency	Percent		Frequency	Percent	Frequency	Percent
0	96	61.9	107	52.5	No	59	38.1	75	36.8
1	34	21.9	75	36.8	Yes	96	61.9	129	63.2
Missing	25	16.1	22	10.8					
Total	155	100.0	204	100.0	Total	155	100.0	204	100.0

Table 4 below displays the grade distribution of students enrolled in MAT 1440/MAT 1445 during 2016 and 2017 respectively. As can be seen in the table, the number of students who completed MAT 1440 with a grade of “D” or better in 2016 compared to MAT 1445 in 2017 increased from 107 (69.0 percent) to 155 (76.1 percent). It should also be noted that 93 of the 204 students enrolled in MAT 1445 in 2017 enrolled as a direct result of a corequisite remediation policy being implemented at the research site. Were it not for this policy, these 93 students would not have been permitted to enroll in MAT 1445 in 2017. Of these 93 students, 69 or 74.2 percent earned a grade of “D” or better. Thus, by implementing the policy these 69 students completed MAT 1445 one semester earlier than what would have occurred were the policy not implemented.

Table 4: Grade distribution in Quantitative Literacy

Grade Distribution—MAT 1440/MAT 1445							
2016/Spring—MAT 1440				2017/Spring—MAT 1445			
Letter Grade	Frequency	Percent	Cumulative Percent	Letter Grade	Frequency	Percent	Cumulative Percent
A	16	10.3	10.3	A	35	17.2	17.2
B	27	17.4	27.7	B	54	26.5	43.7
C	41	26.5	54.2	C	42	20.6	64.3
D	23	14.8	69.0	D	24	11.8	76.1
F	28	18.1	87.1	F	26	12.7	88.8
W	20	12.9	100.0	W	23	11.3	100.1*
Total	155	100.0	N/A	Total	204	100.0	N/A

*The Cumulative Percent did not sum to 100 percent due to rounding error.

Introductory Statistics—MAT 1450

During 2016 there was a total of 106 students enrolled in classroom sections of Introductory Statistics (MAT 1450). In contrast, during 2017 there was a total of 103 students enrolled in classroom sections of Introductory Statistics (MAT 1450). This means that 2.8 percent fewer students were enrolled in MAT 1450 in 2017 compared to 2016, and MAT 1450 is in fact the only gateway course in this study to experience a decline in enrollment.

Table 5: Frequency distribution of enrollment in Introductory Statistics by PBFEM status and Pell Flag

MAT 1450 Introductory Statistics									
PBFEM Status					Pell Flag				
	2016/Spring		2017/Spring			2016/Spring		2017/Spring	
Label	Frequency	Percent	Frequency	Percent	Pell Flag	Frequency	Percent	Frequency	Percent
0	71	67.0	64	62.1	No	48	45.3	46	44.7
1	20	18.9	25	24.3	Yes	58	54.7	57	55.3
Missing	15	14.2	14	13.6					
Total	106	100.0	103	100.0	Total	106	100.0	103	100.0

Table 5 shows that the relative frequencies and the percentage of students enrolled in MAT 1450 during 2017 who were flagged as “Pell-eligible” at some point in their tenure at the research site remained relatively stable compared to 2016. Table 5 also displays the relative frequencies and the percentage of students enrolled in Introductory Statistics (MAT 1450) in 2016 compared to 2017 based on their PBFEM status. As illustrated in the table, a slightly larger percentage of the students enrolled in Introductory Statistics in 2017 compared to 2016 were flagged as being a Performance Based Funding Eligible Minority. This increase was likely the result of variation in enrollment patterns at the research site.

Table 6 below displays the grade distribution of students enrolled in Introductory Statistics in 2016 compared to 2017. As can be seen in the table, the percentage of students who completed Introductory Statistics with a grade of “D” or better in 2016 compared to 2017 increased from 76.3 percent to 85.4 percent. It should also be noted that 30 of the 103 students enrolled in MAT 1450 in 2017 enrolled as a direct result of the corequisite remediation policy being implemented at the research site. Of these, 26 or 86.7 percent earned a grade of “D” or better. By implementing the policy, these 26 additional students were able to complete MAT 1450 one semester earlier than what would have occurred were the policy not implemented.

Table 6: Grade distribution in Introductory Statistics

Grade Distribution--MAT 1450 Introductory Statistics							
2016/Spring				2017/Spring			
Letter Grade	Frequency	Percent	Cumulative Percent	Letter Grade	Frequency	Percent	Cumulative Percent
A	38	35.8	35.8	A	21	20.4	20.4
B	19	17.9	53.7	B	33	32.0	52.4
C	21	19.8	73.5	C	30	29.1	81.5
D	3	2.8	76.3	D	4	3.9	85.4
F	14	13.2	89.5	F	8	7.8	93.2
W	11	10.4	99.9*	W	7	6.8	100.0
Total	106	100	N/A	Total	103	100.0	N/A
*The Cumulative Percent did not sum to 100 percent due to rounding error.							

College Algebra—MAT 1470

Table 7 shows that the relative frequencies and the percentage of students enrolled in MAT 1470 during 2017 who were flagged as Pell-eligible at some point in their tenure at the research site remained relatively stable compared to 2016. This table also displays the relative frequencies and the percentage of students enrolled in MAT 1470 during the same time frame based on their PBFEM status. As illustrated in the table, a larger percentage of students in 2017 compared to 2016 were flagged as a PBFEM. The various changes in the percentage of students flagged as Pell-eligible and PBFEDM were likely the result of variation in enrollment patterns at the research site.

Table 7: Frequency distribution of enrollment in College Algebra by PBFEM status and Pell Flag

MAT 1470 College Algebra									
PBFEM Status					Pell Flag				
	2016/Spring		2017/Spring			2016/Spring		2017/Spring	
Label	Frequency	Percent	Frequency	Percent	Pell Flag	Frequency	Percent	Frequency	Percent
0	126	64.3	267	67.9	No	82	41.8	165	42.0
1	29	14.8	76	19.3	Yes	114	58.2	228	58.0
Missing	41	20.9	50	12.8					
Total	196	100.0	393	100.0	Total	196	100.0	393	100.0

During 2016 there were a total of 196 students enrolled in classroom sections of College Algebra while in 2017 there was a total of 393 students enrolled in classroom sections of College Algebra. This represents a 101 percent increase in enrollment. The course prerequisite to both Introductory Statistics and College Algebra is a grade of “C” or better in Intermediate Algebra. In addition, students may also enroll in either Introductory Statistics and College Algebra based on a satisfactory score on the math placement test. In 2016, 736 students were enrolled in Intermediate Algebra with 56.5 percent of those students successfully completing the course with a grade of “C” or better. In 2017, 495 students were enrolled in Intermediate Algebra with 49.5 percent of those students successfully completing the course with a grade of “C” or better. One possible explanation for the enrollment increase in College Algebra is that students who were eligible to enroll in Intermediate Algebra in 2017 may have instead elected to enroll in College Algebra as a result of implementing corequisite remediation.

Table 8 below displays the grade distribution of students enrolled in College Algebra in 2016 and 2017. As can be seen in the table, the percentage of students who completed College Algebra with a grade of “D” or better in 2016 compared to 2017 decreased from 56.5 percent

to 55.0 percent. College Algebra was the first gateway course in the study, in contrast to both Introductory Statistics and Quantitative Literacy, which experienced a decrease in the percentage of students who completed the course with a grade of “D” or better. One possible explanation for this decrease in the course success rate is the higher level of rigor associated with College Algebra, in contrast to both Introductory Statistics and Quantitative Literacy, which is designed to prepare students to take Calculus (MAT 2270), while the other two courses are primarily designed to prepare students for non-STEM majors. It should be noted though that 214 of the 393 students enrolled in MAT 1470 in 2017 as a direct result of a corequisite remediation policy being implemented at the research site. Of these, 103 or 48.1 percent, earned a grade of “D” or better, while 86 or 40.2 percent earned a grade of “C” or better. As a result of implementing the policy, these 103 students were able to complete MAT 1470 one semester earlier than what would have occurred were the policy not in place. Further study will need to be conducted at the research site to determine whether additional curriculum changes are needed to better support the academic achievement of MAT 1470 students who elect to take the course via corequisite remediation.

Table 8: Grade Distribution – MAT 1470 College Algebra

Grade Distribution--MAT 1470 College Algebra							
2016/Spring				2017/Spring			
Letter Grade	Frequency	Percent	Cumulative Percent	Letter Grade	Frequency	Percent	Cumulative Percent
A	14	7.1	7.1	A	45	11.5	11.5
B	34	17.3	24.4	B	54	13.7	25.2
C	43	21.9	46.3	C	81	20.6	45.8
D	20	10.2	56.5	D	36	9.2	55.0
F	37	18.9	75.4	F	77	19.6	74.6
W	48	24.5	99.9*	W	100	25.4	100.0
Total	196	100.0	N/A	Total	393	100.0	N/A

*The Cumulative Percent did not sum to 100 percent due to rounding error.

Overall Grade Distributions

The intent of Research Question 1 (RQ1) was to broadly assess the impact of a corequisite remediation policy on the number of students who successfully completed selected gateway mathematics courses with a grade of “D” or better. Table 9 below provides a summary of the combined enrollment and grade distributions in the gateway mathematics courses. The combined or average course success rates for all students in the selected gateway mathematics courses who earned a grade of “D” or better in 2017 compared to 2016 stayed the same at 65.5 percent. Additionally, the total number of students who successfully completed the gateway courses with a grade of “D” or better in 2016 compared to 2017 increased from 299 to 459, a 53.5 percent increase. It should be noted that 337 or 48.1 percent of the 700 students enrolled in gateway mathematics courses in 2017 were able to do so as a direct result of corequisite remediation, and that 198 (58.9 percent) of these students successfully completed their required gateway mathematics course with a grade of “D” or better one semester earlier than what would have occurred if the policy were not implemented. In closing, descriptive statistics

confirm that implementing a corequisite remediation policy in selected gateway mathematics courses increased the number of students who successfully completed their required gateway mathematics course with a grade of “D” or better in 2017 compared to 2016.

Table 9: Grade Distributions – MAT 1440/1445, 1450, & 1470

Grade Distributions--MAT 1440/1445, 1450, & 1470							
2016/Spring				2017/Spring			
Letter Grade	Frequency	Percent	Cumulative Percent	Letter Grade	Frequency	Percent	Cumulative Percent
A	68	14.9	14.9	A	101	14.4	14.4
B	80	17.5	32.4	B	141	20.1	34.5
C	105	23.0	55.4	C	153	21.9	56.4
D	46	10.1	65.5	D	64	9.1	65.5
F	79	17.3	82.8	F	111	15.9	81.4
W	79	17.3	100.1*	W	130	18.6	100.0
Total	457	100.0	N/A	Total	700	100.0	N/A
*The Cumulative Percent did not sum to 100 percent due to rounding error.							

RESEARCH QUESTION 2: FINDINGS AND ANALYSES

Research Question 2 (RQ2) focuses on the critical matter of assessing the impact of implementing corequisite remediation, in contrast to prerequisite remediation, on student achievement. To accomplish this, a Chi-Square test was used to compare the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation (Booster students) to the proportion of students who successfully completed the same gateway mathematics courses via prerequisite remediation (Non-booster students) and thus determine whether a significant difference in the performance of these two populations existed. In particular, RQ2 poses the following question:

Was there a significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to the proportion of students who successfully completed the same course with a grade of “D” or better via prerequisite remediation?

In order to determine whether to reject or fail to reject the null hypothesis, for each of the respective gateway courses, the students were sorted into two groups based on whether they enrolled in the course via corequisite remediation or prerequisite remediation. Next, the Final Course Grade (FGRD) of the students was recoded or converted using SPSS from a letter grade to a “1” denoting success or a “0” denoting non-success, as summarized in Table 8 below. As noted previously, the researcher defined “success” as earning a grade of “D” or better since (1) all three selected gateway courses could be considered a terminal course in that successful completion of the course would satisfy the mathematics requirement needed for students to either graduate or transfer to a four-year university and (2) from the standpoint of Ohio’s Performance Based Funding metrics, institutions of higher learning receive state funding, for each student who earns a grade of “D” or higher.

Table 10: Converting a letter grade to the numerical equivalents of Success/Non-success

Final Course Grade	FGRD
A, B, C, D	1= Success
F, W	0 = Non-success

It should be noted that students who withdrew (after the eighth day of the semester but before the last published day to withdraw at the research site which generally occurs around the 12th week of the semester) from the gateway course and earned a grade of “W” were included in the data set and classified as a non-success so that the statistical impact of

withdrawing from class would be analyzed. Additionally, students who were deemed college-ready were excluded from the analyses since they did not require remediation.

For RQ2, the null and alternative hypotheses are the following:

Null Hypothesis

For students enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better. Hence, $H_0: u_1 = u_2$.

Alternative Hypothesis

For students enrolled in selected gateway mathematics courses, there was a significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better. Hence, $H_1: u_1 \neq u_2$.

Quantitative Literacy (MAT 1445)—RQ2

For Quantitative Literacy (MAT 1445), a total of 204 students were enrolled in 2017. However, 31 students were excluded from the analysis since they were deemed college-ready and thus qualified to directly enroll in MAT 1445. Of these, five students were enrolled in Booster sections while the remaining 26 students were enrolled in Non-booster sections. Thus, the academic achievement of 173 students were analyzed in this section with 80 of those students having enrolled in MAT 1445 via prerequisite remediation (Non-booster) and the remaining 93 students enrolled in MAT 1445 as a result of corequisite remediation (Booster).

Table 11 below shows that of the 93 students who were enrolled in Booster sections of MAT 1445, 69 or 74.2 percent were successful; with 24 or 25.8 percent unsuccessful. In

contrast, of the 80 students who were enrolled in Non-booster sections, 64 or 80.0 percent were successful, with 16 or 20.0 percent unsuccessful.

Table 11: Contingency Table of Success Rates of Students in MAT 1445 by Type of Remediation in 2017

	Booster Sections		Non-Booster Sections	
Success	Observed Count	69	Observed Count	64
	Expected Count	71.5	Expected Count	61.5
Non-Success	Observed Count	24	Observed Count	16
	Expected Count	21.5	Expected Count	18.5
Percent Successful		74.2	Percent Successful 80.0	

When performing the Chi-Square test, the null hypothesis assumes that for students enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of students who successfully completed a given course via corequisite remediation with a grade of “D” or better, compared to the proportion of students who successfully completed the same gateway course with a grade of “D” or better via prerequisite remediation. As illustrated in Table 12 below, the critical value of the Chi-Square statistic was 0.816 with a p value of .366. Since the p value of .366 is greater than the alpha level of .05, the researcher fails to reject the null hypothesis and concludes there was no significant difference in the proportion of students who successfully completed Quantitative Literacy via corequisite remediation, compared to prerequisite remediation. In other words, the success of students in MAT 1445 was independent of whether students enrolled via corequisite remediation or prerequisite remediation.

Table 12: Chi-square Tests of students in MAT 1445 during 2017

	Value	df	Asymptotic Significance (2- sided)	Exact Sig. (2-sided)	Exact Sig. (1- sided)
Pearson Chi-Square	.816	1	.366		
Continuity Correction ^b	.522	1	.470		
Likelihood Ratio	.821	1	.365		
Fisher's Exact Test				.470	.236
N of Valid Cases	173				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 18.5.					
b. Computed only for a 2x2 table					

Introductory Statistics (MAT 1450)—RQ2

For Introductory Statistics (MAT 1450), a total of 103 students were enrolled in 2017. However, 30 students were excluded from the analysis since they were deemed college-ready and were thus qualified to directly enroll in MAT 1450. Of these, one student enrolled in a Booster section while the remaining 29 students enrolled in Non-booster sections. Thus, the academic achievement of 73 students were analyzed in this section, with 43 of those students having enrolled in MAT 1450 via prerequisite remediation (Non-booster), and the remaining 30 students enrolled as a result of corequisite remediation (Booster).

Table 13 below shows that of the 30 students who were enrolled in Booster sections of MAT 1450, 26 or 86.7 percent were successful, with 4 or 13.3 percent as unsuccessful. In contrast, of the 43 students who were enrolled in Non-booster sections, 35 or 81.4 percent were successful, while 8 students or 18.6 percent were unsuccessful.

Table 13: Contingency Table of Success Rates of Students in MAT 1450 by Type of Remediation in 2017

	Booster Sections		Non-Booster Sections	
Success	Observed Count	26	Observed Count	35
	Expected Count	25.1	Expected Count	35.9
Non-Success	Observed Count	4	Observed Count	8
	Expected Count	4.9	Expected Count	7.1
Percent Successful		86.7	Percent Successful 81.4	

When performing the Chi-Square test, the null hypothesis assumes that for students enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of students who completed a given course via corequisite remediation with a grade of “D” or better, compared to the proportion of students who completed the same gateway course with a grade of “D” or better via prerequisite remediation. As can be seen in Table 13 above, one cell has an expected count less than five. As a result, the Pearson Chi-Square test may not be used to interpret the results. Rather, Fisher’s Exact Test must be used in this instance. Assuming an alpha level of .05, Fisher’s Exact Test yields a p -value of .750, which is greater than the alpha level of .05. Since the p -value is greater than the alpha level of .05, the researcher fails to reject the null hypothesis and concludes that there was not a significant difference in the proportion of students who successfully completed Introductory Statistics via corequisite remediation compared to prerequisite remediation. In other words, the success of students in MAT 1450 was independent of whether students enrolled via corequisite remediation or prerequisite remediation.

Table 14: Chi-square Tests of students in MAT 1450 in 2017

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.357 ^a	1	.550		
Continuity Correction ^b	.077	1	.782		
Likelihood Ratio	.364	1	.546		
Fisher's Exact Test				.750	.396
N of Valid Cases	73				
a. 1 cell (0.0%) have expected count less than 5. The minimum expected count is 4.93.					
b. Computed only for a 2x2 table					

College Algebra (MAT 1470)—RQ2

For College Algebra (MAT 1470), a total of 393 students were enrolled as of the subsidy date in 2017. It should be noted that 57 students were excluded from this analysis since they were deemed college-ready and permitted to directly enroll in MAT 1470. Of these 57 students, eight students were enrolled in Booster sections while the remaining 49 students were enrolled in Non-booster sections. Thus, for RQ2, a total of 336 students were analyzed, with 122 students enrolled in MAT 1470 as a result of prerequisite remediation while 214 students were enrolled as a result of corequisite remediation.

Table 15 below shows that of the 214 students who were enrolled in Booster sections of MAT 1470, 103 (48.1 percent) were successful, with 111 (51.9 percent) unsuccessful. In contrast, of the 122 students who were enrolled in Non-booster sections, 81 or 66.4 percent were successful with 41 (33.6 percent) unsuccessful. Considering the extremely low success

rate of students who were enrolled in Booster sections compared to students in Non-booster sections, the research site should consider investigating (1) whether adequate instructional supports were embedded in the curriculum of Booster sections and (2) whether some Booster students are more likely to be at-risk of being unsuccessful compared to others.

Table 15: Contingency Table of Success Rates of Students in MAT 1470 by Type of Remediation in 2017

	Booster Sections		Non-Booster Sections	
Success	Observed Count	103	Observed Count	81
	Expected Count	117.2	Expected Count	66.8
Non-Success	Observed Count	111	Observed Count	41
	Expected Count	96.8	Expected Count	55.2
Percent Successful		48.1	Percent Successful	66.4

When performing the Chi-Square test, the null hypothesis assumes that for students enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of students who successfully completed a given course via corequisite remediation with a grade of “D” or better compared to the proportion of students who successfully completed the same gateway course via prerequisite remediation with a grade of “D” or better.

As illustrated in Table 16 below, the critical value of the Chi-Square statistic was 10.461 with a p value of .001. The Phi value of -0.176, illustrated in Table 17 below, indicates that the association between the variables was small and inversely related. Since the Chi-Square’s p -value of .001 is less than the alpha level of .05, the researcher rejects the null hypothesis and concludes that there was a significant difference in the proportion of students who successfully completed College Algebra via corequisite remediation compared to prerequisite remediation.

In other words, the success of students in MAT 1470 was significantly related to whether they were enrolled via corequisite remediation or prerequisite remediation.

Table 16: Chi-square Tests of students in MAT 1470 in 2017

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.461 ^a	1	.001		
Continuity Correction ^b	9.737	1	.002		
Likelihood Ratio	10.607	1	.001		
Fisher's Exact Test				.001	.001
N of Valid Cases	336				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 55.2.					
b. Computed only for a 2x2 table					

Table 17: MAT 1470 Symmetric Measures

		Value	Asymptotic Standard Error ^a	Approximate T ^b	Approximate Significance
Nominal by Nominal	Phi	-.176			.001
	Cramer's V	.176			.001
Ordinal by Ordinal	Kendall's tau-b	-.176	.053	-3.319	.001
N of Valid Cases		336			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					

RESEARCH QUESTION 3: FINDINGS AND ANALYSES

As was noted previously, the State of Ohio's performance-based funding formula was intentionally designed to incentivize institutions (Boudaris, 2014) to implement strategies which support the success of students from underrepresented populations. Thus, the primary goal of

Research Question 3 was to assess the impact of a new initiative such as corequisite remediation on the academic achievement of underrepresented populations; namely, students flagged as a Performance Based Funding Eligible Minority or PBFEM. To accomplish this, Research Question 3 (RQ3) will use a Chi-Square test to compare the proportion of PBFEM students who enrolled in and successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation (Booster students) to the proportion of PBFEM students who enrolled in and successfully completed the same gateway mathematics courses via prerequisite remediation (Non-booster students), and determine whether a significant difference in the proportion of these two populations existed. In particular, Research Question 3 asks the following question:

For students flagged as a Performance Based Funding Eligible Minority (PBFEM) enrolled in selected gateway mathematics courses, was there a significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better via corequisite remediation (Booster students) compared to the proportion of PBFEM students who successfully completed the same course with a grade of “D” or better via prerequisite remediation (Non-booster students)?

For Research Question 3, the null and alternative hypotheses are the following:

Null Hypothesis for RQ3

For students flagged as a PBFEM who were enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better via corequisite remediation (Booster students) compared to the proportion of PBFEM students who successfully completed the same course with a grade of “D” or better via prerequisite remediation (Non-booster students). Hence, for $H_0: u_1 = u_2$.

Alternative Hypothesis

For students flagged as a PBFEM who were enrolled in selected gateway mathematics courses, there was a significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better via corequisite remediation (Booster students) compared to the proportion of PBFEM students who

successfully completed the same course with a grade of “D” or better via prerequisite remediation (Non-booster students). Hence, for $H_1: u_1 \neq u_2$.

In order to determine whether to reject or fail to reject the null hypothesis for each of the respective gateway courses, the students were sorted into two groups based on whether they were flagged as a PBFEM. Next, the Final Course Grade (FGRD) of the students who were flagged as a PBFEM was recoded or converted using SPSS from a letter grade to a “1” denoting Success or a “0” denoting Non-success, as summarized in Table 16. Additionally, students who did not self-report their race or ethnicity were flagged in the institution’s database as “unknown” and were thus excluded from this analysis since the researcher would be unable to appropriately classify the student.

Quantitative Literacy (RQ3—MAT 1445)

A total of 204 students were enrolled in Quantitative Literacy (MAT 1445) in 2017. As noted previously though, 31 of those students were excluded from analysis since they were deemed college-ready and thus qualified to directly enroll in MAT 1445. Of the remaining 173 students who were enrolled in MAT 1445, the PBFEM-status of 20 students was classified as “unknown” with 13 of those students being enrolled in booster sections of MAT 1445, and 7 of those students enrolled in non-Booster sections. Since the PBFEM-status of these students was unknown, they were excluded from analysis in RQ3. Thusly, this portion of RQ3 focuses on the 65 students who were flagged as a PBFEM and enrolled in MAT 1445. RQ4 focuses on the remaining 88 students flagged as a Non-PBFEM that were enrolled in MAT 1445.

Table 18 below shows that of the 65 students who were flagged as a Performance Based Funding Eligible Minority (PBFEM), 44 of these students enrolled in Booster sections of

MAT 1445 while 21 students were enrolled in non-booster sections of MAT 1445. Of the 44 PBFEM students who were enrolled in booster sections, 32 or 72.7 percent were successful, with 12 or 27.3 percent unsuccessful. In contrast, of the 21 PBFEM students who were enrolled in non-booster sections, 14 or 66.7 percent were successful with 7 or 33.3 percent unsuccessful.

Table 18: Contingency Table of Success Rates of PBFEM Students in MAT 1445 by Type of Remediation in 2017

	Booster Sections		Non-Booster Sections	
Success	Observed Count	32	Observed Count	14
	Expected Count	31.1	Expected Count	14.9
Non-Success	Observed Count	12	Observed Count	7
	Expected Count	12.9	Expected Count	6.1
Percent Successful		72.7	Percent Successful	
			66.7	

When performing the Chi-Square test, the null hypothesis assumes that for PBFEM students enrolled in MAT 1445 there was no significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better in booster sections compared to non-booster sections. As can be seen in Table 19 below, the critical value of the Chi-Square statistic was 0.252 with a p value of 0.615. Since the p value of .615 is greater than the alpha level of .05, the researcher fails to reject the null hypothesis and concludes there was no significant difference in the proportion of PBFEM students who successfully completed Quantitative Literacy via corequisite remediation, compared to prerequisite remediation. In other words, the success of PBFEM students in MAT 1445 was independent of whether students enrolled via corequisite remediation or prerequisite remediation.

Table 19: Chi-square Tests of PBFEM students in MAT 1445 in 2017.

	Value	df	Asymptotic Significance (2- sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.252 ^a	1	.615		
Continuity Correction ^b	.044	1	.883		
Likelihood Ratio	.249	1	.618		
Fisher's Exact Test				.771	.411
Linear-by-Linear Association	.249	1	.618		
N of Valid Cases	65				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.14.					
b. Computed only for a 2x2 table					

Introductory Statistics (RQ3—MAT 1450)

A total of 103 students were enrolled in Introductory Statistics (MAT 1450) in 2017. As noted previously though, 30 of those students were excluded from the analysis since they were deemed college-ready and thus qualified to directly enroll in MAT 1450. Of the remaining 73 students who were enrolled in MAT 1450, the PBFEM-status of 11 students was classified as “unknown” with four of those students being enrolled in booster sections of MAT 1450 and the remaining seven students enrolled in non-booster sections. Since the PBFEM status of these students was unknown, they were excluded from this analysis.

This portion of RQ3 focuses on the 17 students flagged as a PBFEM that were enrolled in MAT 1450 while RQ4 will focus on the remaining 45 students flagged as a non-PBFEM that were enrolled in MAT 1450. Due to the extremely small sample size, a Chi-Square test was not run for PBFEM students enrolled in MAT 1450.

College Algebra (RQ3—MAT 1470)

A total of 393 students were enrolled in College Algebra (MAT 1470) in 2017. As noted previously though, 57 students were excluded from this analysis since they were deemed college-ready and permitted to directly enroll in MAT 1470. Of these, eight students were enrolled in booster sections while the remaining 49 students were enrolled in non-booster sections. Of the remaining 336 students who were enrolled in MAT 1470, the PBFEM-status of 48 students was classified as “unknown” with 30 of those students being enrolled in booster sections of MAT 1470 and the remaining 18 students enrolled in non-booster sections. Since the PBFEM-status of these students was unknown, they were excluded from this analysis. Thus, this portion of RQ3 focuses on the 69 students flagged as a PBFEM that were enrolled in MAT 1470. while RQ4 will focus on the remaining 219 students flagged as a non-PBFEM who were enrolled in MAT 1470.

Table 20 below shows that of the 69 students who were flagged as a Performance Based Funding Eligible Minority (PBFEM); 40 of these students enrolled in booster sections of MAT 1470 while 29 students were enrolled in non-booster sections of MAT 1470. Of the 40 PBFEM students who were enrolled in booster sections, 17 or 42.5 percent were successful, with 23 or 57.5 percent as unsuccessful. In contrast, of the 29 PBFEM students who were enrolled in non-booster sections, 18 or 62.1 percent were successful, with 11 or 14.3 percent unsuccessful.

Table 20: Contingency Table of Success Rates of PBFEM Students in MAT 1470 by Type of Remediation in 2017

Booster Sections			Non-Booster Sections	
Success	Observed Count	17	Observed Count	18
	Expected Count	20.3	Expected Count	14.7
Non-Success	Observed Count	23	Observed Count	11
	Expected Count	19.7	Expected Count	14.3
Percent Successful		42.5	Percent Successful	
			62.1	

When performing the Chi-Square test, the null hypothesis assumes that for PBFEM students enrolled in MAT 1470 there was no significant difference in the proportion of PBFEM students who successfully completed the course with a grade of “D” or better in booster sections, compared to non-booster sections.

As can be seen in Table 21 below, the critical value of the Chi-Square statistic was 2.576 with a p value of .109. Since the p value of 0.109 is greater than the alpha level of .05, the researcher fails to reject the null hypothesis and concludes that there was no significant difference in the proportion of PBFEM students who successfully completed College Algebra via corequisite remediation compared to prerequisite remediation. In other words, the success of PBFEM students in MAT 1470 was independent of whether students enrolled via corequisite remediation or prerequisite remediation.

Table 21: Chi-square Tests on PBFEM students in MAT 1470 in 2017

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	2.576 ^a	1	.109		
Continuity Correction	1.852	1	.174		
Likelihood Ratio	2.595	1	.107		
Fisher's Exact Test				.145	.087
Linear-by-Linear Association					
N of Valid Cases	69				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 14.29. b. Computed only for a 2x2 table					

RESEARCH QUESTION 4: FINDINGS AND ANALYSES

Research Question 4 (RQ4) is an extension of Research Question 3 in that RQ4 seeks to examine the academic achievement, as measured by the Final Course Grade (FGRD), of students in selected gateway mathematics courses who were not flagged as a Performance Based Funding Eligible Minority or Non-PBFEM students. To accomplish this, a Chi-Square test will be used to compare the proportion of Non-PBFEM students who successfully completed selected gateway mathematics courses via corequisite remediation (Booster students) to that of Non-PBFEM students who completed the same course via prerequisite remediation and determine whether a significant difference in the performance of these two populations exists.

Research Question 4 asks the following question:

For students enrolled in selected gateway mathematics courses, was there a significant difference in the proportion of Non-Performance Based Funding Eligible Minority (Non-PBFEM) students who successfully completed the course via corequisite remediation (Booster students) with a grade of “D” or better, compared to Non-Performance Based

Funding Eligible Minority (Non-PBFEM) students who successfully completed the course via prerequisite remediation (Non-booster students) with a grade of “D” or better?

For Research Question 4, the null and alternative hypotheses are the following:

Null Hypothesis

For students flagged as a Non-PBFEM enrolled in selected gateway mathematics courses, there was no significant difference in the proportion of Non-PBFEM students who successfully completed the course via corequisite remediation (Booster students) with a grade of “D” or better compared to Non-PBFEM students who successfully completed the course via prerequisite remediation (Non-booster students) with a grade of “D” or better. Hence, for $H_0: u_1 = u_2$.

Alternative Hypothesis

For students flagged as a Non-PBFEM enrolled in selected gateway mathematics courses, there was a significant difference in the proportion of Non-PBFEM students who successfully completed the course via corequisite remediation (Booster students) with a grade of “D” or better compared to Non-PBFEM students who successfully completed the course via prerequisite remediation (Non-booster students) with a grade of “D” or better. Hence, for $H_1: u_1 \neq u_2$.

Quantitative Reasoning (RQ4—MAT 1445)

As noted previously, a total of 88 students were flagged as a Non-PBFEM and enrolled in MAT 1445 in 2017. Table 22 below shows that of the 88 Non-PBFEM students, 36 students enrolled via corequisite remediation in MAT 1445, while 52 students enrolled in MAT 1445 via prerequisite remediation. Of the 36 Non-PBFEM students who enrolled via corequisite remediation, 28 or 77.8 percent were successful; 8 or 22.2 percent unsuccessful. In contrast, of the 52 Non-PBFEM students who enrolled in MAT 1445 via prerequisite remediation, 43 or 82.7 percent were successful, with 9 or 17.3 percent unsuccessful.

Table 22: Contingency Table of Success Rates of Non-PBFEM Students in MAT 1445 by Type of Remediation in 2017

Booster Sections			Non-Booster Sections	
Success	Observed Count	28	Observed Count	43
	Expected Count	29.0	Expected Count	42.0
Non-Success	Observed Count	8	Observed Count	9
	Expected Count	7.0	Expected Count	10.0
Percent Successful		77.8	Percent Successful	82.7

When performing the Chi-Square test, the null hypothesis assumes that for Non-PBFEM students enrolled in MAT 1445, there was no significant difference in the proportion of Non-PBFEM students who successfully completed the course with a grade of “D” or better in booster sections compared to non-booster sections.

As can be seen in Table 23 below, the critical value of the Chi-Square statistic was 0.330 with a p value of .566. Since this p value is greater than .05, the researcher fails to reject the null hypothesis and concludes that there was no significant difference in the proportion of Non-PBFEM students who successfully completed Quantitative Literacy via corequisite remediation compared to prerequisite remediation. In other words, the success of Non-PBFEM students in MAT 1445 was independent of whether students enrolled in the course via corequisite remediation or prerequisite remediation.

Table 23: Chi-square Tests on Non-PBFEM students in MAT 1445 in 2017.

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	.330 ^a	1	.566		
Continuity Correction	.090	1	.765		
Likelihood Ratio	.327	1	.568		
Fisher's Exact Test				.593	.379
Linear-by-Linear Association	.326	1	.568		
N of Valid Cases	88				
a. 0 cells (0.0%) have expected count less than 6.95.					
b. Computed only for a 2x2 table					

Introductory Statistics (RQ4—MAT 1450)

As noted previously, a total of 45 students flagged as a Non-PBFEM were enrolled in MAT 1450 2017. Of these, 17 Non-PBFEM students were enrolled in booster sections of MAT 1450 while the remaining 28 Non-PBFEM students were enrolled in non-booster sections. Due to the extremely small sample size, a Chi-Square test was not run on Non-PBFEM students enrolled in MAT 1450.

College Algebra (RQ4—MAT 1470)

As noted previously, a total of 393 students were enrolled in MAT 1470 in 2017, which includes 219 students who were flagged as a Non-PBFEM. Table 24 below shows that of the 219 Non-PBFEM students, 144 students enrolled in booster sections of MAT 1470 while 75 students enrolled in non-booster sections. Of the 144 Non-PBFEM students who were enrolled in booster sections, 74 or 51.4 percent were successful, while 70 or 48.6 percent were

unsuccessful. In contrast, of the 75 Non-PBFEM students who were enrolled in non-booster sections, 52 or 69.3 percent were successful, with 23 or 30.7 percent unsuccessful.

Table 24: Contingency Table of Success Rates of Non-PBFEM Students in MAT 1470 by Type of Remediation in 2017

Booster Sections			Non-Booster Sections	
Success	Observed Count	74	Observed Count	52
	Expected Count	82.8	Expected Count	43.2
Non-Success	Observed Count	70	Observed Count	23
	Expected Count	61.2	Expected Count	31.8
Percent Successful		51.4	Percent Successful	69.3

When performing the Chi-Square test, the null hypothesis assumes that for Non-PBFEM students enrolled in MAT 1470, there was no significant difference in the proportion of Non-PBFEM students who successfully completed the course with a grade of “D” or better in booster sections compared to non-booster sections.

As can be seen in Table 25 below, the critical value of the Chi-Square statistic was 6.499 with a p value of .011. Since this p value is less than .05, the researcher rejects the null hypothesis and concludes there was a significant difference in the proportion of Non-PBFEM students who successfully completed College Algebra via corequisite remediation compared to prerequisite remediation. The Phi value of -0.172 indicates that the association between the variables was small and inversely related. Hence, the success of Non-PBFEM students in MAT 1470 was significantly related to whether the student enrolled in the course via corequisite remediation or prerequisite remediation, but the strength of the association was weak. Thus,

Non-PBFEM students were more likely to be successful in MAT 1470 if they enrolled in the course through prerequisite remediation compared to corequisite remediation.

Table 25: Chi-square Tests on Non-PBFEM students in MAT 1470 in 2017

MAT 1470: Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	6.499 ^a	1	.011*		
Continuity Correction	5.786	1	.016		
Likelihood Ratio	6.630	1	.010		
Fisher's Exact Test				.014	.008
N of Valid Cases	219				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 31.85.					
b. Computed only for a 2x2 table					
MAT 1470 Symmetric Measures					
		Value	Asymptotic Standard Error ^a	Approx. T ^b	Approximate Significance
Nominal by Nominal	Phi	-.172			.011
	Cramer's V	.172			.023
Ordinal by Ordinal	Kendall's tau-b	-.172	.065	-2.636	.008
N of Valid Cases		219			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					

RESEARCH QUESTION 5: FINDINGS AND ANALYSES

Research Question 5 (RQ5) will use a Chi-Square test to compare the academic achievement of students in selected gateway mathematics courses who were flagged as ever being eligible for a Pell grant based on the type of course remediation they experienced in 2017. Moreover, students for which no information concerning their Pell eligibility status was known were excluded from analysis. Hence, Research Question 5 asks the following question:

For students enrolled in selected gateway mathematics courses who were flagged as ever being eligible to receive a Pell grant, was there a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students)?

For Research Question 5, the null and alternative hypotheses are the following:

Null Hypothesis

For students enrolled in selected gateway mathematics courses who were flagged as ever being eligible to receive a Pell grant, there was no significant difference in the proportion of these students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to those students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for $H_0: u_1 = u_2$.

Alternative Hypothesis

For students enrolled in selected gateway mathematics courses who were flagged as ever being eligible to receive a Pell grant, there was a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for $H_1: u_1 \neq u_2$.

In order to determine whether to reject or fail to reject the null hypothesis, for each of the respective gateway courses, the data file supplied by RAR was processed so that it only contained students who had been flagged as ever being eligible to receive a Pell grant. Then, the Final Course Grade (FGRD) of all students in the data set was recoded or converted using SPSS from a letter grade to a “1” denoting Success or a “0” denoting Non-success using the mapping summarized in Table 10. Finally, a Chi-Square test was then used to determine whether the success of students who were flagged as ever being eligible to receive a Pell grant was independent of whether the student completed the gateway course via corequisite remediation (booster student) or prerequisite remediation (non-booster student).

Quantitative Literacy (RQ5—MAT 1445)

A total of 204 students were enrolled in Quantitative Literacy (MAT 1445) in 2017. As noted previously though, 31 of those students were excluded from analysis since they were deemed college-ready and thus qualified to directly enroll in MAT 1445. Of the remaining 173 students in the data set, 54 students were not flagged as ever being Pell-eligible and removed from the data base, leaving 119 students who were flagged as ever being Pell-eligible at some point in time while enrolled at the institution to be analyzed as part of RQ5.

Table 26 below shows that of the 119 students who were flagged as ever being Pell-eligible at some point in time while enrolled at the institution 65 students were enrolled in booster sections of MAT 1445 while 54 students were enrolled in non-booster sections of MAT 1445. Of the 65 students who were flagged as ever being Pell-eligible and enrolled in booster sections, 50 or 76.9 percent were successful, with 15 or 23.1 percent unsuccessful. In contrast, of the 54 students who were flagged as ever being Pell-eligible and enrolled in non-booster sections, 42 or 77.8 percent were successful with 12 or 22.2 percent unsuccessful.

Table 26: Contingency Table of Success Rates of Pell Students in MAT 1445 by Type of Remediation in 2017

Booster Sections			Non-Booster Sections	
Success	Observed Count	50	Observed Count	42
	Expected Count	50.3	Expected Count	41.7
Non-Success	Observed Count	15	Observed Count	12
	Expected Count	14.7	Expected Count	12.3
Percent Successful		76.9	Percent Successful	77.8

When performing the Chi-Square test, the null hypothesis assumes that for students enrolled in MAT 1445 who were flagged as ever being eligible to receive a Pell grant while at the institution, there was no significant difference in the proportion of these students who successfully completed the course with a grade of “D” or better in booster sections compared to non-booster sections.

As can be seen in Table 27 below, the critical value of the Chi-Square statistic was .012 with a p value of .912. Since this p value is greater than .05, the researcher fails to reject the null hypothesis and concludes that there was no significant difference in the proportion of students who were flagged as ever being eligible to receive a Pell grant while at the institution and who successfully completed Quantitative Literacy via corequisite remediation compared to prerequisite remediation. In other words, the success of students who were flagged as ever being eligible to receive a Pell grant while at the institution was independent of whether students enrolled via corequisite remediation or prerequisite remediation.

Table 27: Chi-square Tests on Pell students in MAT 1445 in 2017

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.012 ^a	1	.912		
Continuity Correction	.000	1	1.000		
Likelihood Ratio	.012	1	.912		
Fisher’s Exact Test				1.000	.545
Linear-by-Linear Association	.012	1	.912		
N of Valid Cases	119				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 12.25.					
b. Computed only for a 2x2 table					

Quantitative Literacy (RQ5—MAT 1450)

For Introductory Statistics (MAT 1450), a total of 103 students were enrolled as of the subsidy date in 2017. However, 30 of those students were excluded from the analysis since they were deemed college-ready and were qualified to directly enroll in MAT 1450. Of the remaining 73 students in the data set, 45 students were flagged as having been Pell-eligible at some point in time while enrolled at the institution with the remaining 28 students not being flagged. Due to the extremely small sample size, a Chi-Square test was not run on MAT 1450 students flagged as having been Pell-eligible at some point in time while enrolled at the institution.

College Algebra (RQ5—MAT 1470)

A total of 393 students were enrolled in College Algebra (MAT 1470) in 2017. As noted previously though, 57 students were excluded from this analysis since they were deemed college-ready and permitted to directly enroll in MAT 1470. Of the remaining 336 students in the data set, 131 students were not flagged as ever being Pell-eligible with 205 students flagged as being Pell-eligible at some point in time while enrolled at the institution.

Table 28 below indicates that of the 205 students who were flagged as being Pell-eligible at some point in time while enrolled at the institution 129 of these students were enrolled in booster sections of MAT 1470, while 76 students enrolled in non-booster sections of MAT 1470. Of the 129 students who were flagged as ever being Pell-eligible and enrolled in booster sections, 54 or 41.9 percent were successful, with 75 or 58.1 percent unsuccessful. In

contrast, of the 76 students who were flagged as ever being Pell-eligible and enrolled in non-booster sections 49 or 64.5 percent were successful with 27 or 35.5 percent unsuccessful.

Table 28: Contingency Table of Success Rates of Pell Students in MAT 1470 by Type of Remediation in 2017

Booster Sections			Non-Booster Sections		Total
Success	Observed Count	54	Observed Count	49	103
	Expected Count	64.8	Expected Count	38.2	
Non-Success	Observed Count	75	Observed Count	27	102
	Expected Count	64.2	Expected Count	37.8	
% Successful Booster		41.9%	% Successful Non-Booster		64.5%

When performing the Chi-Square test, the null hypothesis assumes that for students enrolled in MAT 1470 who were ever flagged as being eligible to receive a Pell grant while at the institution, there was no significant difference in the proportion of these students who successfully completed the course with a grade of “D” or better in booster sections compared to non-Booster sections.

As can be seen in Table 29 below, the critical value of the Chi-Square statistic was 9.782 with a p value of .002. Since this p value is less than .05, the researcher rejects the null hypothesis and concludes that there was a significant difference in the proportion of students who were flagged as ever being eligible to receive a Pell grant while at the institution and who successfully completed College Algebra via corequisite remediation compared to prerequisite remediation. The Phi value of -0.218 indicates that the association between the variables was small and inversely related. It is worth noting that the success rate of ever-Pell-eligible, Non-booster students was 22.6 percentage points higher than the success rate of ever-Pell-eligible, Booster students. Thus, College Algebra students who were flagged as ever being eligible to

receive a Pell grant while at the institution and enrolled in non-booster sections were more likely to be successful than their counterparts who were enrolled in booster sections. The higher success rate of Non-booster students who were flagged as ever being eligible to receive a Pell grant, compared to their booster counterparts, may be due to the former group of students having stronger foundational skills in mathematics since these students would have successfully completed the course prerequisite with a grade of “C” or higher. Further study is needed to understand the reason for the higher success rate of ever-Pell, Non-booster students to their ever-Pell, booster counterparts.

Table 29: Chi-square Tests on Pell students in MAT 1470 in 2017

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	9782 ^a	1	.002*		
Continuity Correction	8.889	1	.003		
Likelihood Ratio	9.889	1	.002		
Fisher’s Exact Test				.002	.001
N of Valid Cases	205				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 37.81.					
b. Computed only for a 2x2 table					
MAT 1470 Symmetric Measures					
		Value	Asymptotic Standard Error ^a	Approx. T ^b	Approximate Significance
Nominal by Nominal	Phi	-.218			.002
	Cramer’s V	.218			.002
Ordinal by Ordinal	Kendall’s tau-b	-.218	.068	-3.207	.001
N of Valid Cases		205			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					

RESEARCH QUESTION 6: FINDINGS AND ANALYSES

Research Question 6 (RQ6) focuses solely on students who have not been flagged as ever being eligible for a Pell grant. Research Question 6 asks the following question:

For students enrolled in selected gateway mathematics courses who have not been flagged as ever being eligible to receive a Pell grant, was there a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to the proportion of students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students)?

For Research Question 6, the null and alternative hypotheses are the following:

Null Hypothesis

For students enrolled in selected gateway mathematics courses who have not been flagged as ever being eligible to receive a Pell grant, there was no significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for $H_0: u_1 = u_2$.

Alternative Hypothesis

For students enrolled in selected gateway mathematics courses who have not been flagged as ever being eligible to receive a Pell grant, there was a significant difference in the proportion of students who successfully completed the course via corequisite remediation with a grade of “D” or better (Booster students) compared to students who successfully completed the same course via prerequisite remediation with a grade of “D” or better (Non-booster students). Hence, for $H_1: u_1 \neq u_2$.

Using a process similar to what was described in RQ5, students who were flagged as ever being eligible to receive a Pell grant were eliminated from the data file which in turn left students who have not been flagged as ever being eligible to receive a Pell grant. A Chi-Square test was used to determine whether the success of students who have not been flagged as ever being eligible to receive a Pell grant independent of whether a student completed the course

via corequisite remediation (Booster student) or prerequisite remediation (Non-booster student).

Quantitative Literacy (RQ6—MAT 1445)

In 2017, 54 students were enrolled in Quantitative Literacy (MAT 1445) that were not flagged as ever being Pell-eligible at some point in time while enrolled at the. It is these “Non-Pell” students which will be analyzed. Table 30 below shows that of the 54 Non-Pell students, 28 students were enrolled in Booster sections of MAT 1445 while 26 students were enrolled in Non-booster sections of MAT 1445. Of the 28 Non-Pell students who were enrolled in Booster sections, 19 or 67.9 percent were successful; with 9 or 32.1 percent unsuccessful. In contrast, of the 26 Non-Pell students who were enrolled in Non-booster sections, 22 or 84.6 percent were successful, with 4 or 15.4 percent unsuccessful.

Table 30: Contingency Table of Success Rates of Non-Pell Students in MAT 1445 by Type of Remediation in 2017

	Booster Sections		Non-Booster Sections	
Success	Observed Count	19	Observed Count	22
	Expected Count	21.3	Expected Count	19.7
Non-Success	Observed Count	9	Observed Count	4
	Expected Count	6.7	Expected Count	6.3
Percent Successful		67.9	Percent Successful	84.6

When performing the Chi-Square test, the null hypothesis assumes that for students enrolled in MAT 1445 who were not flagged as ever being Pell-eligible at some point in time while enrolled at the institution, there was no significant difference in the proportion of

students who successfully completed the course with a grade of “D” or better in Booster sections compared to Non-Booster sections.

As can be seen in Table 31 below, the critical value of the Chi-Square statistic was 2.071 with a p value of .150. Since this p value is greater than .05, the researcher fails to reject the null hypothesis and concludes that there was not a significant difference in the proportion of students who have not been flagged as ever being eligible to receive a Pell grant while at the institution and who successfully completed Quantitative Literacy via corequisite remediation, compared to prerequisite remediation. In other words, the success of students who have not been flagged as ever being eligible to receive a Pell grant was independent of whether students enrolled via corequisite remediation or prerequisite remediation. It is worth noting that the success rate of “Non-Pell-eligible, Non-booster” students was 16.7 percentage points higher than the success rate of “Non-Pell-eligible, Booster students.” The higher success rate of Non-booster students may be due to having stronger foundational skills in mathematics since these students would have successfully completed the course prerequisite with a grade of “C” or higher. Further study is needed to understand the reason for the higher course success rate of Non-Pell, Non-booster students to that of Non-Pell, Booster students.

Table 31: Chi-square Tests on Non-Pell students in MAT 1445 during 2017

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	2.071 ^a	1	.150		
Continuity Correction	1.256	1	.262		
Likelihood Ratio	2.119	1	.145		
Fisher's Exact Test				.207	.131
Linear-by-Linear Association	2.033	1	.154		
N of Valid Cases	54				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.26.					
b. Computed only for a 2x2 table					

Introductory Statistics (RQ6—MAT 1450)

As noted previously, a total of 103 students were enrolled in Introductory Statistics (MAT 1450) in 2017, which includes 28 students who were not flagged as ever being Pell-eligible at some point in time while enrolled at the institution. Table 32 below shows that of the 28 Non-Pell students, 17 students were enrolled in Booster sections of MAT 1450 while 11 students were enrolled in Non-booster sections of MAT 1450. Due to the extremely small sample size, a Chi-Square test was not run on MAT 1450 students who were not flagged as ever being Pell-eligible at some point in time while enrolled at the institution.

College Algebra (RQ6—MAT 1470)

As noted previously, a total of 393 students were enrolled in College Algebra (MAT 1470) in 2017, which includes 131 students who were not flagged as ever being Pell-eligible at some point in time while enrolled at the institution. Table 32 below shows that of the 131 Non-

Pell students, 85 students were enrolled in Booster sections of MAT 1470 while 46 students were enrolled in Non-booster sections of MAT 1470. Of the 85 Non-Pell students who were enrolled in Booster sections, 49 or 57.6 percent were successful, with 36 or 42.4 percent unsuccessful. In contrast, of the 46 Non-Pell students who were enrolled in Non-booster sections 32 or 69.6 percent were successful, with 14 or 30.4 percent unsuccessful.

Table 32: Contingency Table of Success Rates of Non-Pell Students in MAT 1470 by Type of Remediation in 2017

	Booster Sections		Non-Booster Sections	
Success	Observed Count	49	Observed Count	32
	Expected Count	52.6	Expected Count	28.4
Non-Success	Observed Count	36	Observed Count	14
	Expected Count	32.4	Expected Count	17.6
Percent Successful		57.6	Percent Successful	69.6

When performing the Chi-Square test, the null hypothesis assumes that for students enrolled in MAT 1470 who were not flagged as ever being Pell-eligible (Non-Pell) at some point in time while enrolled at the institution, there was no significant difference in the proportion of students who successfully completed the course with a grade of “D” or better in Booster sections compared to Non-Booster sections.

As can be seen in Table 33 below, the critical value of the Chi-Square statistic was 1.796 with a p value of .180. Since this p value is greater than .05, the researcher fails to reject the null hypothesis and concludes that there was not a significant difference in the proportion of students who have not been flagged as ever being eligible to receive a Pell grant while at the institution who successfully completed College Algebra via corequisite remediation compared

to prerequisite remediation. Thus, the success of Non-Pell students in College Algebra was independent of whether they enrolled in the course via corequisite remediation or prerequisite remediation. Further study is needed to understand the reason for the higher course success rate of Non-Pell, Non-booster students compared to that of Non-Pell, Booster students.

Table 33: Chi-square Tests on Non-Pell students in MAT 1470 in 2017

MAT 1470: Chi-Square Tests					
	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2- sided)	Exact Sig. (1- sided)
Pearson Chi-Square	1.796 ^a	1	.180		
Continuity Correction	1.327	1	.249		
Likelihood Ratio	1.825	1	.177		
Fisher's Exact Test				.193	.124
N of Valid Cases	131				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 17.56.					
b. Computed only for a 2x2 table					

RESEARCH QUESTION 7: FINDINGS AND ANALYSES

The preceding research questions all utilized either descriptive or bivariate statistics to analyze the relationship between the independent and dependent variables. Research Question 7 (RQ7) used logistic regression, a multivariate statistical test, to simultaneously analyze the interaction between dependent, independent, and control variables. Before performing the analysis, the researcher manually coded each student's Initial Math Placement Level (IMPL) in SPSS based on the data set supplied by the institution's Research, Analytics, and Reporting (RAR) department and the criteria listed below in Table 34.

Table 34: Initial Math Placement Level Coding based on Criteria Developed by the Researcher.

IMPL	Criteria
1	First math course enrolled in at the research site that was 1 level below college-level math courses.
2	First math course enrolled in at the research site that was 2 levels below college-level math courses.
3	First math course enrolled in at the research site that was 3 levels or more below college-level math courses.

Research Question 7 posed the following question:

For students enrolled in selected gateway mathematics courses, does the type of remediation (corequisite remediation versus prerequisite remediation) predict academic achievement in selected gateway mathematics courses, as measured by the Final Course Grade (FCG), while controlling for the student's Grade Point Average (GPA) and the student's Initial Math Placement Level (IMPL)?

The control variable Grade Point Average (GPA), represents the students cumulative grade point average as of January 1, 2017. As noted previously, the purpose of including GPA in the analysis was that it provides a longitudinal indicator of student's academic achievement relative to the number of credits completed by the student as of January 1, 2017. GPA is a continuous variable and ranges from 0 to 4, inclusive.

Quantitative Literacy—MAT 1445

For this analysis using logistic regression, a total of 173 cases were analyzed after students who were deemed college-ready were eliminated from the data set. As illustrated in Table 35 below, the average grade point average (GPA) of students who successfully completed

Quantitative Literacy with a grade of “D” or higher was 15.1 percent higher than the average GPA of students who were not successful. Moreover, the average GPA of Non-booster students enrolled in MAT 1445 was 12.3 percent higher than the average GPA of Booster students. On average, students with higher GPAs, were more successful in MAT 1445 than students with lower GPAs and students who were enrolled in Booster sections had lower GPAs than their Non-booster counterparts. Finally, Pearson’s Chi-Square test was performed to test the association between the success or non-success of students in MAT 1445 and their Initial Math Placement Level (IMPL). The null hypothesis assumes that there was no association between the variables. Based on the results of the test, the researcher failed to reject the null hypothesis.

Table 35: Grade Point Average of MAT 1445 Students

	n	GPA
Success	133	2.681
Non-Success	40	2.329
Booster	93	2.459
Non-Booster	80	2.762

The variables Booster, GPA, and IMPL were included in Model 1 to see if they were predictive of success (FGRD). The Omnibus Chi-Square test for the overall fit of Model 1 was not significant at the $p \leq 0.05$ level. The Nagelkerke R Square value obtained, sometimes referred to as the pseudo-R Square value, was 0.057. Hence, approximately 5.7 percent of the variability in the dependent variable (FGRD) is accounted for in the independent variables. The contribution of the variable GPA to Model 1 yielded a p value of 0.019 that was statistically significant at the $p \leq 0.05$ level. However, neither IMPL nor Booster contributed to Model 1 in a

statistically significant manner. An analysis of the odds ratio for the variable GPA in Model 1 shows that for each one-point increase in the student's grade point average, the likelihood of a student completing MAT 1445 with a grade of "D" or better increased by a factor of 1.775. Since the contribution of the variable IMPL to Model 1 was not statistically significant, a new model was created without this variable and analyzed.

Once the variable IMPL was deleted from Model 1 and the analyses conducted once more, the resulting Omnibus Chi-Square Test for the overall fit of Model 2 was also statistically significant at the $p \leq 0.05$ level. Similar to Model 1, the contribution of the variable GPA was statistically significant at the $p \leq 0.05$ level but the contribution of the variable Booster was not statistically significant at the $p \leq 0.05$ level, as shown in Table 36 below. The Nagelkerke R Square value for Model 2 was 0.056. Hence, approximately 5.6 percent of the variability in the dependent variable was accounted for in the independent variables. An analysis of the odds ratio for the variable GPA in Model 2 shows that for each one-point increase in the student's cumulative grade point average, the likelihood of a student completing MAT 1445 with a grade of "D" or better increased by a factor of 1.756.

Based on the analyses of Models 1 and 2, the researcher concludes that the type of remediation was not predictive of the academic achievement of students in MAT 1445 when controlling for GPA and IMPL. The analyses showed that the variable GPA significantly contributed to the predictive ability of both models, but the Nagelkerke R Square value suggested that the predictive ability of Models 1 and 2 was very low. Controlling for student's initial math placement level did not significantly contribute to the predictive ability of either model.

Table 36: Models 1 and 2, Variables in the Equation—MAT 1445

Model 1 - Variables in the Equation—MAT 1445							95% C.I. for Exp(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
IMPL			.121	2	.941			
IMPL(1)	.124	.402	.096	1	.757	1.132	.515	2.488
IMPL(2)	.145	.622	.054	1	.816	1.156	.342	3.914
Booster(1)	.145	.381	.145	1	.703	1.156	.548	2.439
GPA	.574	.245	5.491	1	.019	1.775	1.098	2.869
Constant	-.373	.667	.312	1	.577	.689		
Nagelkerke R Square of 0.057								
a. Variable(s) entered on step 1: IMPL, Booster, GPA.								
Model 2—Variables in the Equation—MAT 1445							95% C.I. for Exp(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Booster(1)	.154	.380	.164	1	.685	1.166	.554	2.457
GPA	.563	.238	5.606	1	.018	1.756	1.102	2.800
Constant	-.286	.603	.225	1	.636	.751		
Nagelkerke R Square of 0.056								
a. Variable(s) entered on step 1: Booster, GPA.								

Introductory Statistics—MAT 1450

For this analysis using logistic regression, a total of 73 cases were analyzed after students who were deemed college-ready were eliminated from the data set. As illustrated in Table 37 below, the average grade point average (GPA) of students who successfully completed Introductory Statistics with a grade of “D” or higher was 15.7 percent higher than the average GPA of students who were not successful. Moreover, the average GPA of Non-booster students enrolled in MAT 1450 was 15.5 percent higher than the average GPA of Booster students. On average, students with higher GPAs, were more successful in MAT 1450 than students with lower GPAs and students who were enrolled in Booster sections had lower GPAs than their

Non-booster counterparts. Finally, Pearson’s Chi-Square test was performed to test the association between the success or non-success of students in MAT 1450 and their Initial Math Placement Level (IMPL). The null hypothesis assumes that there was no association between the variables. Based on the results of the test, the researcher failed to reject the null hypothesis.

Table 37: Grade Point Average of MAT 1450 Students

	n	GPA
Success	61	2.857
Non-Success	12	2.470
Booster	30	2.560
Non-Booster	43	2.957

The variables Booster, GPA, and IMPL were included in Model 1 to see if they were predictive of success (FGRD). The Omnibus Chi-Square test for the overall fit of Model 1 was not significant at the $p \leq 0.05$ level. The Nagelkerke R Square value obtained was 0.141. Hence, approximately 14.1 percent of the variability in the dependent variable was accounted for in the independent variables. The contributions of the variable GPA to Model 1 yielded a p value that was statistically significant at the $p \leq 0.05$ level. However, neither IMPL nor Booster contributed to Model 1 in a statistically significant manner. An analysis of the odds ratio for the variable GPA in Model 1 shows that for each one-point increase in the student’s grade point average, the likelihood of a student completing MAT 1450 with a grade of “D” or better increased by a large factor of 3.858. Since the contribution of the variable IMPL to Model 1 was not statistically significant, a new model was created without this variable and analyzed.

Once the variable IMPL was deleted from Model 1 and the analyses were repeated, the resulting Omnibus Chi-Square test for the overall fit of Model 2 was significant at the $p \leq 0.05$ level. Similar to Model 1, the contribution of the variable GPA was statistically significant at the $p \leq 0.05$ level but the contribution of the variable Booster was not statistically significant at the $p \leq 0.05$ level, as shown in Table 38 below. The Nagelkerke R Square value obtained for Model 2 was 0.134. Hence, approximately 13.4 percent of the variability in the dependent variable was accounted for in the independent variables. An analysis of the odds ratio for the variable GPA in Model 2 shows that for each one-point increase in the student's cumulative grade point average, the likelihood of a student completing MAT 1450 with a grade of "D" or better increased by a large factor of 3.977. Thus, students with a cumulative grade point average of 3.0 were almost four times more likely to complete MAT 1450 with a grade of "D" or better, compared to students with a cumulative grade point average of 2.0.

Based on the analyses of Models 1 and 2, the researcher concludes that the type of remediation was not predictive of the academic achievement of students in MAT 1450 when controlling for GPA and IMPL. The analyses showed that the variable GPA significantly contributed to the predictive power of both models, but the Nagelkerke R Square value suggests that the predictive ability of Models 1 and 2 was relatively low. Controlling for student's initial math placement level did not significantly contribute to the predictive ability of either model.

Table 38: Models 1 and 2, Variables in the Equation—MAT 1450

Model 1 - Variables in the Equation—MAT 1450							95% C.I. for Exp(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
IMPL			.337	2	.845			
IMPL(1)	-.478	.839	.325	1	.569	.620	.120	3.209
IMPL(2)	-.191	.869	.049	1	.826	.826	.150	4.531
Booster(1)	-1.037	.836	1.539	1	.215	.355	.069	1.825
GPA	1.350	.617	4.794	1	.029	3.858	1.152	12.919
Constant	-1.081	1.533	.497	1	.481	.339		
Nagelkerke R Square of 0.141								
a. Variable(s) entered on step 1: IMPL, Booster, GPA.								
Model 2—Variables in the Equation—MAT 1450							95% C.I. for Exp(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Booster(1)	-1.097	.794	1.908	1	.167	.334	.070	1.583
GPA	1.381	.618	4.991	1	.025	3.977	1.185	13.354
Constant	-1.358	1.438	.892	1	.345	.257		
Nagelkerke R Square of 0.134								
a. Variable(s) entered on step 1: Booster, GPA.								

College Algebra—MAT 1470

For this analysis using logistic regression, a total of 336 cases were analyzed after students who were deemed college-ready were eliminated from the data set. As illustrated in Table 39 below, the average grade point average (GPA) of students who successfully completed College Algebra with a grade of “D” or higher was 16.7 percent higher than the average GPA of students who were not successful. Moreover, the average GPA of Non-booster students enrolled in MAT 1470 was 2.4 percent higher than the average GPA of Booster. On average, students with higher GPAs, were more successful in MAT 1470 than students with lower GPAs and students who were enrolled in Booster sections had lower GPAs than their Non-booster counterparts. Finally, Pearson’s Chi-Square test was performed to test the association between

the success or non-success of students in MAT 1470 and their Initial Math Placement Level (IMPL). The null hypothesis assumes that there was no association between the variables. Based on the results of the test, the researcher failed to reject the null hypothesis.

Table 39: Grade Point Average of MAT 1470 Students

	n	GPA
Success	184	2.987
Non-Success	152	2.560
Booster	214	2.770
Non-Booster	122	2.836

The variables Booster, GPA, and IMPL were included in Model 1 to see if they were predictive of success (FGRD). The Omnibus Chi-Square Test for the overall fit of Model 1 was significant at the $p \leq 0.001$ level. Table 38 below shows that the Nagelkerke R Square value obtained was 0.153, so approximately 15.3 percent of the variability in the dependent variable is accounted for in the independent variables. Although the variable IMPL did not contribute to the model in a statistically significant way, the contribution of the variable of Booster was statistically significant at the $p \leq 0.01$ level and the contribution of the variable GPA was statistically significant at the $p \leq 0.001$ level. An analysis of the odds ratio for the variable GPA in Model 1 shows that for each one-point increase in the student's cumulative grade point average, the likelihood of a student completing MAT 1470 with a grade of "D" or better increased by a large factor of 2.496. Additionally, an analysis of the odds ratio for the variable Booster in Model 1 shows that for students who enroll in MAT 1470 via prerequisite remediation, in contrast to corequisite remediation, the likelihood of them completing MAT 1470 with a grade of "D" or better increased by a factor of 1.969. Since the contribution of the

variable IMPL to Model 1 was not statistically significant, a new model was created without this variable and analyzed.

Once the variable IMPL was deleted from Model 1 and the analyses repeated, the resulting Omnibus Chi-Square test for the overall fit of Model 2 was significant at the $p \leq 0.001$ level. Additionally, Table 40 below shows that the Nagelkerke R Square value obtained decreased slightly to 0.148 so approximately 14.8 percent of the variability in the dependent variable is accounted for in the independent variables.

The table below also shows that the variables Booster and GPA provided contributions to Model 2 that were statistically significant at the $p \leq 0.01$ and $p \leq 0.001$ levels respectively. An analysis of the odds ratio for the variable GPA in Model 2 shows that for each one-point increase in the student's cumulative grade point average, the likelihood of a student completing MAT 1470 with a grade of "D" or better increased by a large factor of 2.177. Additionally, an analysis of the odds ratio for the variable Booster in Model 2 shows that for students who enroll in MAT 1470 via prerequisite remediation, in contrast to corequisite remediation, the likelihood of them completing MAT 1470 with a grade of "D" or better increased by a factor of 2.441.

Based on the analyses and results of Models 1 and 2, the researcher concludes that the type of remediation was predictive of the academic achievement of students in MAT 1470 while controlling for GPA and IMPL. The analyses showed that the variable GPA significantly contributed to the predictive power of both models, but the Nagelkerke R Square value suggests that the predictive ability of the models was quite low. Controlling for students' initial math placement level did not significantly contribute to the predictive ability of either model.

Table 40: Model 2 - Variables in the Equation—MAT 1470

Model 1 - Variables in the Equation—MAT 1470							95% C.I. for Exp(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
IMPL			1.569	2	.456			
IMPL(1)	.448	.366	1.492	1	.222	1.565	.763	3.209
IMPL(2)	.027	.256	.011	1	.918	1.027	.622	1.696
Booster(1)	.677	.262	6.677	1	.010	1.969	1.178	3.291
GPA	.915	.185	24.495	1	.000	2.496	1.737	3.585
Constant	-2.689	.569	22.302	1	.000	.068		
Nagelkerke R Square of 0.153								
a. Variable(s) entered on step 1: IMPL, Booster, GPA.								
Model 2 - Variables in the Equation—MAT 1470							95% C.I. for Exp(B)	
	B	S.E.	Wald	df	Sig.	Exp(B)	Lower	Upper
Booster(1)	.778	.245	10.073	1	.002	2.177	1.346	3.519
GPA	.893	.183	23.908	1	.000	2.441	1.707	3.492
Constant	-2.583	.541	22.753	1	.000	.076		
Nagelkerke R Square of 0.148								
a. Variable(s) entered on step 1: Booster, GPA.								

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

The purpose of this study was to examine the impact of a corequisite remediation model, in contrast to the traditional prerequisite remediation model, in selected gateway mathematics courses at a large, urban, community college located in the downtown business district of the sixth largest city in the State of Ohio. In particular, does the use of corequisite remediation, in contrast to prerequisite remediation, (1) increase the number of students successfully completing selected gateway mathematics courses and, (2) improve student achievement, as measured by the final course grade, in selected gateway mathematics courses? The outcome of these questions has the potential to influence whether institutions utilize corequisite remediation as a strategy to increase student completion of gateway mathematics courses.

Descriptive statistics were used to determine whether a policy of corequisite remediation increased the number of students successfully completing selected gateway mathematics courses with a grade of “D” or better and inferential statistics were used to determine whether there was a significant difference in the proportion of students who successfully completed selected gateway mathematics courses with a grade of “D” or better via corequisite remediation compared to prerequisite remediation. Additionally, inferential statistics were used to analyze the performance of various sub-populations of students who

enrolled in the gateway courses via corequisite remediation compared to prerequisite remediation while logistic regression was used to determine whether the type of remediation (corequisite versus prerequisite) was predictive of student success in selected gateway mathematics courses while controlling for students cumulative grade point average and their initial mathematics placement level (IMPL).

STUDENT COMPLETION AND COREQUISITE REMEDIATION

After implementing corequisite remediation at the research site, fewer students enrolled in both Beginning (Mat 1270) and Intermediate Algebra (MAT 1355/1365 & 1370) in 2017 compared to 2016 while enrollment in the gateway courses to which these courses serve as course prerequisites increased. Although determining the reasons for these enrollment changes was outside the scope of this study, it appears that some type of “enrollment transference” occurred in 2017 with the introduction of a corequisite remediation policy. Descriptive statistics presented in this study showed that the overall number of students who successfully completed selected gateway mathematics courses at the research site in 2016 compared to 2017 increased from 299 to 459, a 53.5 percent increase. Of the 459 students who successfully completed one of the gateway mathematics courses included in the study in 2017, 198 (Booster) students, or 43.1 percent, enrolled in and successfully completed a gateway course as a direct result of a policy of corequisite remediation being implemented at the research site. Additionally, these Booster students were able to complete their gateway mathematics course one semester earlier than what would have occurred if they had enrolled

in their gateway course via prerequisite remediation. This result should be viewed as an additional benefit of implementing a policy on corequisite remediation.

As described in Chapter Four of this study, the number of students successfully completing the gateway mathematics courses examined in this study increased after the research site implemented a policy of corequisite remediation. However, the actual breakdown by course is telling. Only 48.1 percent of students who enrolled in College Algebra as a direct result of corequisite remediation successfully completed the course with a grade of “D” or better. In contrast, of the students who enrolled in the other two courses via corequisite remediation, 74.2 percent of Quantitative Literacy students and 86.7 percent of Introductory Statistics students successfully completed their respective gateway course with a grade of “D” or better. These results suggest that implementing corequisite remediation at the research site may have been more effective in both Quantitative Literacy and Introductory Statistics than College Algebra.

The primary goal of College Algebra is to provide students with the foundational knowledge needed to be successful in trigonometry and ultimately calculus. To be successful in College Algebra, students must have a firm understanding of the prerequisite content found in Beginning Algebra, but the content in Intermediate Algebra is also important since the definitions, skills, and concepts contained in Intermediate Algebra such as factoring and solving quadratic equations are essential to solving more complicated problems in College Algebra such as finding the solution to higher order polynomial equations or graphing conic sections.

In this study, why was the success rate of students who enrolled in College Algebra via corequisite remediation so different from the success rates of students who enrolled in the

other two courses via corequisite remediation? Perhaps successful completion of College Algebra, in contrast to both Quantitative Literacy and Introductory Statistics, is more dependent on mastery of prerequisite knowledge. Hence, it's possible that the amount of time devoted to instruction in the Booster course that students take at the same time as College Algebra was insufficient to support successful completion of College Algebra compared to the amount of time devoted to instruction in the Booster courses paired with both Quantitative Literacy and Introductory Statistics respectively.

In 2016, 56.5 percent of students enrolled in College Algebra successfully completed the course with a grade of "D" or better while in Quantitative Literacy and Introductory Statistics course success rates were 69.0 and 76.3 percent respectively. One possible explanation for a lower course success rate in College Algebra compared to the other two courses is that College Algebra is a more rigorous and demanding course compared to both Quantitative Literacy and Introductory Statistics. If so, it's not surprising that in 2017 course success rates in College Algebra (for both Booster and Non-booster students) were lower compared to the other two courses, regardless of whether a student enrolled in the other courses via corequisite remediation or prerequisite remediation.

To summarize, descriptive statistics confirmed that implementing a corequisite remediation strategy contributed to more students successfully completing gateway mathematics courses in 2017 compared to the number of students who successfully completed gateway mathematics courses in 2016 via prerequisite remediation. However, descriptive statistics suggest that course success rates of students who enrolled in College Algebra via corequisite remediation requires further study to determine why the success rate of these

students was lower compared to the success rates of students who enrolled in both Quantitative Literacy and Introductory Statistics via corequisite remediation.

ACADEMIC ACHIEVEMENT OF STUDENTS AND COREQUISITE REMEDIATION

Chi-Square tests found no significant difference in the proportion of students who successfully completed Quantitative Literacy or Introductory Statistics via corequisite remediation, compared to prerequisite remediation. However, a Chi-Square test did reveal that there was a significant difference in the proportion of students who successfully completed College Algebra via corequisite remediation compared to prerequisite remediation.

An analysis of the average of the cumulative GPAs of Non-booster students in College Algebra revealed that their average GPA was higher than the average of the cumulative GPAs of Booster students who were enrolled in College Algebra. These same trends occurred for students enrolled in both Quantitative Literacy and Introductory Statistics. Perhaps weaker students, as measured by their cumulative GPA, were weeded out after taking the course immediately prerequisite to the gateway courses, leaving only students with higher cumulative GPAs to take the gateway courses, while students with lower cumulative GPAs enrolled in the gateway courses via corequisite remediation because they perceived this pathway as a means of obtaining the support needed for them to be successful in the gateway courses. Even though the average of the cumulative GPAs of Booster students enrolled in gateway courses was lower than the average of the cumulative GPAs of Non-booster students in the gateway courses, it should be reiterated that there was no significant difference in the proportion of students who successfully completed Quantitative Literacy or Introductory Statistics via corequisite

remediation compared to prerequisite remediation. However, as noted previously, there was a significant difference in the proportion of students who successfully completed College Algebra via corequisite remediation, compared to prerequisite remediation. Additional longitudinal data needs to be collected and studied at the research site to determine whether this trend occurs in subsequent semesters and to determine why the trend occurs.

The overall proportion of students who successfully completed the gateway courses via corequisite remediation (58.8 percent) was lower compared to that of prerequisite remediation (73.5 percent). Moreover, 198 additional students successfully completed their gateway course one semester earlier than what would have occurred had a policy of corequisite remediation not been implemented at the research site. To reiterate, corequisite remediation allowed these 198 students to complete their gateway mathematics course faster than prerequisite remediation would have. Hence, the researcher recommends that the research site continue to provide students the option of enrolling in Quantitative Literacy, Introductory Statistics, and College Algebra via corequisite remediation. However, the research site should consider conducting additional research to determine whether enrollment in a course via corequisite remediation needs to be restricted based on the student's grade point average.

Two critical metrics used by the researcher in this study to assess the impact of corequisite remediation on student completion of selected gateway mathematics courses are throughput (examining the total number of students completing a gateway mathematics course) and academic achievement. As described above, implementing corequisite remediation at the research clearly increased the total number of students completing selected gateway mathematics courses in 2017 compared to 2016, or throughput.

The academic achievement of students in this study was examined by using a Chi Square test to determine whether there was a significant difference in the proportion of students who successfully completed selected gateway mathematics courses, with a grade of “D” or better, via corequisite remediation compared to prerequisite remediation. For Quantitative Literacy and Introductory Statistics, Chi Square tests revealed there was no significant difference in the proportion of students in these classes who successfully completed their respective courses with a grade of “D” or better via corequisite remediation compared to prerequisite remediation. Additionally, for Quantitative Literacy, a higher proportion of Non-Booster students, compared to Booster students, successfully completed the course with a grade of “D” or better while, for Introductory Statistics, a higher proportion of Booster students, compared to Non-Booster students, successfully completed the course with a grade of “D” or better. Nevertheless, for both courses, Chi Square tests indicated that there was no significant difference in the performance of these proportions. Finally, for College Algebra, a higher proportion of Non-Booster students, compared to Booster students, successfully completed the course with a grade of “D” or better and a Chi Square test indicated that there was a significant difference in these proportions.

When assessing the impact or effectiveness of a new strategy, the hope is that the new strategy (corequisite remediation) is superior to the old or current strategy (prerequisite remediation). The results of this study have confirmed that corequisite remediation increased the number of students who successfully completed selected gateway mathematics courses with a grade of “D” or better. The study also showed, for two out of three courses, no significant difference in the proportion of students who successfully completed selected

gateway courses via corequisite remediation compared to prerequisite remediation with a grade of “D” or better. The study also revealed that there was only one course (Introductory Statistics) for which a larger proportion of Booster students, compared to Non-Booster students, successfully completed the mathematics course; although this difference was not statistically significant. Considering these results, the researcher has insufficient evidence to conclude that corequisite remediation, as a model, is superior to that of prerequisite remediation. At a minimum, data from the study indicates that corequisite remediation, compared to prerequisite remediation, increased the number of students who successfully completed selected gateway mathematics courses and, more importantly, reduced the number of semesters it takes students to complete their gateway course.

ACADEMIC ACHIEVEMENT OF SUB-POPULATIONS AND COREQUISITE REMEDIATION

A Chi-Square test was used to analyze the performance of four different sub-populations of students who enrolled in selected gateway mathematics courses via corequisite remediation compared to prerequisite remediation. In Quantitative Literacy (MAT 1445), Chi-Square tests found no significant difference in the proportion of students who successfully completed MAT 1445 for the following sub-populations of students: PBFEM, Non-PBFEM, Pell-eligible, and Non-Pell. Due to small sample sizes, the same four sub-populations of students could not be examined for Introductory Statistics (MAT 1450) using Chi-Square. However, sample sizes were sufficiently large to permit the same four sub-populations to be examined in College Algebra (MAT 1470). In MAT 1470, there was a significant difference in the proportion of PBFEM students, Non-PBFEM students, and Pell-eligible students who successfully

completed the course via corequisite remediation compared to prerequisite remediation but there was no significant difference in the proportion of Non-Pell students who successfully completed College Algebra via corequisite remediation compared to prerequisite remediation.

It should be noted that a higher percentage of PBFEM students who enrolled in College Algebra via prerequisite remediation successfully completed the course compared to the percentage of PBFEM students who successfully completed the course via corequisite remediation. Similar results occurred for both Non-PBFEM students and Pell-eligible students. The research site should consider conducting additional research to understand why a significantly higher proportion of College Algebra students from three out of four sub-populations (PBFEM, Non-PBFEM, Pell-eligible) of students successfully completed the course via prerequisite remediation compared to prerequisite remediation.

PREDICTIVE ABILITY OF THE TYPE OF REMEDIATION

Logistic regression analyses found that (1) students' cumulative grade point average was predictive of success in all three gateway courses included in this study, and (2) the type of remediation was predictive of success in College Algebra but was not predictive of success in Quantitative Literacy or Introductory Statistics. For College Algebra, an analysis of the odds ratio for the variable Booster in Model 2 showed that for students who enroll in College Algebra via prerequisite remediation, in contrast to corequisite remediation, the likelihood of the former completing College Algebra increased by a factor of 2.441. Additionally, controlling for student's initial math placement level (IMPL) did not significantly contribute to the predictive ability of either of the two models examined for College Algebra and it did not significantly

contribute to the predictive ability of any of the models examined for either Quantitative Literacy or Introductory Statistics.

As noted above, student's initial math placement level (IMPL) did not significantly contribute to the ability of any of the models to predict student completion of the gateway courses included in this study. This result appears to run counter to the work of Roksa, Jenkins, Jaggars, Zeidenberg, and Cho (2009) which found that "Students who were recommended to take lower level developmental courses were less likely to enroll in courses or complete the developmental sequence than those recommended to take higher level courses". In this study, student IMPL was determined based on the initial math course taken. The advantages of determining a student's IMPL in this way is that the researcher did not have to (1) make decisions as to how to assess one placement test score (Accuplacer, ACT, Compass) compared to another, (2) make decisions about how to handle missing placement test scores, or (3) make decisions about including or excluding a given student in the study based on whether a student's placement test score was his or her first attempt at the placement test or third attempt. Additionally, the data set used to perform logistic regression included students who may have taken their first mathematics course at the research site more than 10 years ago. So, is a student whose IMPL was two levels below college level based on taking his first math course in the Fall of 2006 as prepared as a student whose IMPL was two levels below college level based on taking his first math course in the Fall of 2016? The answer might depend on a variety of factors such as how motivated is the student to succeed, if the student experienced any financial or personal hardships during the semester, if a pay raise or promotion was dependent on the student successfully completing the course, and so forth.

In light of the results of the logistic regression analysis, perhaps a student's initial mathematics placement level did not contribute to the predictive power of the regression models because the method used to determine the student's initial mathematics placement level did not accurately determine the student's true IMPL. Alternately, perhaps a student's initial mathematics placement level did not contribute to the predictive power of the regression models because it is not important where a student begins his or her journey to complete a gateway mathematics course, but whether the student is willing to actively and consistently participate in the learning process. In other words, to what extent do non-cognitive factors such as motivation or socioeconomic status, combined with a student's initial math placement level influence whether a student ultimately completes his gateway mathematics course? Further study is needed to determine whether a student's initial math placement level contributes to the predictive ability of the models.

RECOMMENDATIONS FOR FURTHER RESEARCH

A number of recommendations have already been made highlighting various aspects of this study which require additional research. An additional area worthy of further study is the success of students who participate in corequisite remediation, in contrast to prerequisite remediation, when both the gateway course and the Booster course are delivered in a fully online modality. In 2017, all sections of gateway mathematics courses in the study which were delivered via corequisite remediation were done so in a traditional, face-to-face setting. The primary reason this occurred at the research site was that development of online versions of the Booster courses did not begin until after the face-to-face versions were implemented in the

Spring of 2017. In general, roughly 25 percent of the total enrollment at the research site in a given semester occurs via online courses. According to Friedman (2018), “more than 6.3 million students in the U.S. – most of whom were undergraduates – took at least one online course in fall 2016, a 5.6 percent increase from the previous year” (para. 2). In order to ensure that the institution serves the broadest possible audience, the research site began offering gateway courses via corequisite remediation in an online format in Fall 2017. Given the difficulties associated with learning mathematics in an online environment and the results of this study, additional research is needed to assess the effectiveness of corequisite remediation delivered in an online modality.

As noted in this study, the type of remediation was predictive of success in College Algebra but not predictive of success in Quantitative Literacy or Introductory Statistics. This study also found that only 48.1 percent of students who enrolled in College Algebra via corequisite remediation successfully completed the course with a grade of “D” or better. Additional research may be needed to measure the change or increase in learning of students who enroll in College Algebra via corequisite remediation, compared to prerequisite remediation, by a study which utilizes a pre- and post-test design. Or perhaps analyze the success of students in their next mathematics course based on whether they completed College Algebra via corequisite remediation compared to prerequisite remediation. Finally, it may be informative to undertake a qualitative study of the experiences of students who enrolled in the gateway courses via corequisite remediation compared to prerequisite remediation to better understand the differences in the academic achievement of these two populations.

Another area worthy of additional research is an examination of the actual cost and revenue associated with implementing corequisite remediation in contrast to prerequisite remediation. In 2016, a total of 457 students were enrolled in 21 sections of gateway mathematics courses, while in 2017 a total of 700 students were enrolled in 41 sections of gateway mathematics courses with 337 of these students enrolled in 40 sections of Booster courses. This equates to a 95.2 percent increase in the number of gateway course sections that were offered at the research site in 2017 as compared to 2016. Further, it also meant that the research site needed to staff (in a single semester) approximately 20 additional gateway course sections in 2017, as compared to 2016, due to implementing corequisite remediation. Criteria provided by the Higher Learning Commission, the regional accrediting body of the research site, stipulate that faculty who teach in general education programs should possess either a master's degree in the discipline or a master's degree plus 18 graduate credit hours in the discipline (Higher Learning Commission, 2016). Since the availability of master's-trained educators can fluctuate greatly, it is possible that the institution needed to obtain additional full-time faculty to (1) ensure that it possessed a sufficient number of faculty to teach the increased number of gateway courses and (2) ensure that it had faculty trained to teach courses delivered via corequisite remediation since adjunct faculty may not possess the requisite skills and/or training. Ultimately, the potential to incur higher personnel costs with corequisite remediation, compared to prerequisite remediation, call in to question the ability of the research site and other institutions to sustain a policy of corequisite remediation. As a result, further study is needed to fully assess the cost of implementing corequisite remediation in contrast to prerequisite remediation.

CONCLUSIONS

Achieving the Dream and other national initiatives have highlighted the efforts of both two- and four-year institutions to improve student completion of both developmental and gateway mathematics courses. States such as Florida, Tennessee, Texas, and Virginia have been early adopters of a variety of strategies designed to improve student completion of gateway courses such as the emporium model, eliminating developmental or remedial coursework as a prerequisite to college-level coursework, multiple measures (the use of high school transcripts and other metrics to place students into English and mathematics courses at two- and four-year institutions), and corequisite remediation. Results of implementing these strategies can vary from state to state but Hu et al. (2016) found that overall enrollment rates in developmental math, English and writing declined by 16, 11, and five percentage points respectively after colleges and universities in Florida were prohibited from requiring high school graduates to enroll in remedial coursework, while the percentage of students completing gateway English and math courses increased by 7 percentage points and 4 percentage points respectively. Hu et al. (2016) also noted that the proportion of all students in a given cohort that passed a gateway course increased while individual course passing rates declined. Additionally, a study conducted by the Tennessee Board of Regents found that 54.8 percent of AY 2015 – 16 students who participated in a corequisite mathematics program received a passing grade in a credit-bearing mathematics course compared to 12.3 percent of AY 2012 – 13 students who enrolled via prerequisite remediation (Denley, 2016).

States such as Florida, Tennessee, Texas, and Virginia are to be commended for their boldness and willingness to put the success of their students first as they sought more effective

ways of increasing the number of students completing gateway mathematics courses without “dumbing down” the curriculum. Because of their boldness, states like California, Minnesota, and Ohio have begun exploring strategies such as corequisite remediation. In fact, in February 2018, Ohio was one of three states selected to receive a grant from Strong Start to Finish (SSTF), designed to increase college completion rates while closing the attainment gap for underserved populations (Strong Start to Finish, n.d.). A key strategy used by colleges and universities participating in SSTF to meet its stated goals is to implement corequisite remediation of gateway English and mathematics courses at scale. This study echoes the results of these other states; namely, that corequisite remediation can be an effective strategy and is deserving of additional research and structured implementation in at least some gateway mathematics courses. According to Bailey, et al. (2010), as few as one-third of students in mathematics ever complete the course sequence to which they were assigned through prerequisite remediation. Given these statistics, it is not surprising that more colleges and universities are considering corequisite remediation as a means of improving student completion of gateway courses.

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APPENDIX A: IRB APPROVAL LETTERS

February 27, 2018

Anthony M. Ponder
Dean of Science, Math, and Engineering
Sinclair Community College

RE: Corequisite Mathematics

Dear Tony:

As chair of the Sinclair Institutional Review Board for the Protection of Human Subjects (IRB00005624), I am writing to inform you that I have reviewed your proposal and approved the continuation/modification of your research project as it continues to meet the criteria for exempt status as established by the U.S. Department of Health and Human Services under category two. As such, this proposal has been determined to be exempt from the full IRB review under Section 101, subsection b.1 and compliant with Sinclair protocols.

Any serious adverse events or issues relating from this study should be reported immediately to the IRB. Additionally, any changes to protocols or informed consent documents must have IRB approval before implementation.

If you have any questions or concerns, please feel free to contact me. Good luck with your research.

Sincerely,



Chad Atkinson, Ph.D.
Manager of Research
Sinclair Community College, Research, Analytics, and Reporting
Chair, Sinclair Institutional Review Board
Phone: 937-512-4118
chad.atkinson-9026@sinclair.edu

January 24, 2017

Anthony M. Ponder
Dean of Science, Mathematics, and Engineering
Sinclair Community College

RE: Corequisite Mathematics

Dear Tony:

As chair of the Sinclair Institutional Review Board for the Protection of Human Subjects (IRBOOO05624), I am writing to inform you that I have reviewed your proposal and approved the protocol as it meets the criteria for exempt status as established by the U.S. Department of Health and Human Services under category two. Please note that exempt proposals need not be reviewed by the full IRB (see Section 101, subsection b.1). Your planned research is fully compliant with Sinclair protocols.

Any serious adverse events or issues relating from this study must be reported immediately to the IRB. Additionally, any changes to protocols or informed consent documents must have IRB approval before implementation.

If you have any questions or concerns, please feel free to contact me. Good luck with your research.

Sincerely,



Chad Atkinson, Ph.D.
Manager of Research
Sinclair Community College, Research, Analytics, and Reporting
Chair, Sinclair Institutional Review Board
Phone: 937-512-4118
chad.atkinson4026@sinclair.edu

Institutional Review Board for Human Subjects in Research

Office of Research & Sponsored Programs, 1010 Campus Drive 410G · Big Rapids, MI 49307

Date: March 6, 2018
To: Dr. Sandra Balkema and Mr. Anthony Ponder
From: Dr. Gregory Wellman, IRB Chair
Re: IRB Application #161203 (*The Impact on Student Completion of Co-Requisite Parings of Remedial and College-Level Mathematics Courses*)

The Ferris State University Institutional Review Board (IRB) has reviewed your request for revisions in the study, "*The Impact on Student Completion of Co-Requisite Parings of Remedial and College-Level Mathematics Courses*" (#161203) and determined that it meets Federal Regulations Exempt-category 1A. This approval follows the expiration date of your initial application approval. As such, you may collect data according to the procedures outlined in your application until January 25, 2020. Should additional time be needed to conduct your approved study, a request for extension must be submitted to the IRB a month prior to its expiration.

Approval mandates that you follow all University policy and procedures, in addition to applicable governmental regulations. Approval applies only to the activities described in the protocol submission; should revisions need to be made, all materials must be approved by the IRB prior to initiation. In addition, the IRB must be made aware of any serious and unexpected and/or unanticipated adverse events as well as complaints and non-compliance issues.

This project has been granted a waiver of consent documentation; signatures of participants need not be collected. Although not documented, informed consent is a process beginning with a description of the study and participant rights, with the assurance of participant understanding. Informed consent must be provided, even when documentation is waived, and continue throughout the study via a dialogue between the researcher and research participant.

As mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) the IRB requires submission of annual reviews during the life of the research project and a Final Report Form upon study completion. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,



Ferris State University Institutional Review Board
Office of Research and Sponsored Programs

Institutional Review Board for Human Subjects in Research

Office of Research & Sponsored Programs, 1010 Campus Drive 410G · Big Rapids, MI 49307

Date: January 25, 2017
To: Dr. Sandra Balkema and Mr. Anthony Ponder
From: Dr. Gregory Wellman, IRB Chair
Re: IRB Application #161203 (*The Impact on Student Completion of Co-Requisite Parings of Remedial and College-Level Mathematics Courses*)

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, "*The Impact on Student Completion of Co-Requisite Parings of Remedial and College-Level Mathematics Courses*" (#161203) and determined that it meets Federal Regulations Exempt-category 1A. This approval has an expiration date of three years from the date of this letter. As such, you may collect data according to the procedures outlined in your application until January 25, 2020. Should additional time be needed to conduct your approved study, a request for extension must be submitted to the IRB a month prior to its expiration.

Your protocol has been assigned project number (#161203), which you should refer to in future correspondence involving this same research procedure. Approval mandates that you follow all University policy and procedures, in addition to applicable governmental regulations. Approval applies only to the activities described in the protocol submission; should revisions need to be made, all materials must be approved by the IRB prior to initiation. In addition, the IRB must be made aware of any serious and unexpected and/or unanticipated adverse events as well as complaints and noncompliance issues.

This project has been granted a waiver of consent documentation; signatures of participants need not be collected. Although not documented, informed consent is a process beginning with a description of the study and participant rights, with the assurance of participant understanding. Informed consent must be provided, even when documentation is waived, and continue throughout the study via a dialogue between the researcher and research participant.

As mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) the IRB requires submission of annual reviews during the life of the research project and a Final Report Form upon study completion. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,



Ferris State University Institutional Review Board
Office of Research and Sponsored Programs Version 1.2015