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The Effects of Stem and Non-stem Mathematics Corequisite Courses on Student Success at Public Institutions in West Virginia

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THE EFFECTS OF STEM AND NON-STEM MATHEMATICS COREQUISITE COURSES ON STUDENT SUCCESS AT PUBLIC INSTITUTIONS IN WEST VIRGINIA

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Approved by
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APPROVAL OF DISSERTATION

We, the faculty supervising the work of **Vanessa Keadle**, affirm that the dissertation, **The Effects of Stem and Non-stem Mathematics Corequisite Courses on Student Success at Public Institutions in West Virginia** meets the high academic standards for original scholarship and creative work established by the EdD Program in **Leadership Studies** and the College of Education and Professional Development. This work also conforms to the editorial standards of our discipline and the Graduate College of Marshall University. With our signatures, we approve the manuscript for publication.

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DEDICATION

To Meredith, who taught me that the limit truly does not exist.

To Whit, who never ceases to make me laugh and teaches me every day how to be a better person.

To my Mom, who has shown me that giving in service to others is the purest form of love.

And to my Dad, whose work ethic and passion I can only strive to match.

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holding me while I cried, listening to my endless chatter about mathematics and developmental education reform, and for being a true partner throughout it all. You're my favorite.

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ABSTRACT

This study explored the differences in student success outcomes between students enrolled in non-STEM and STEM corequisite mathematics courses at 18 postsecondary institutions across five academic years in West Virginia, using de-identified student data. The researcher analyzed this extant data to determine if student characteristics were predictors of success, as defined as passing the mathematics corequisite course, retention to the next semester, and earning a GPA of 2.0 or higher. The researcher also conducted analyses to understand if the differences in those outcomes between STEM and non-STEM courses were significant. This study identified statistically significant gaps in success for students who enrolled in STEM and non-STEM courses in retention and earning a GPA of 2.0 or higher. It further identified multiple student characteristics significantly predictive of passing a corequisite mathematics course (i.e., sex, race, Pell status, and mathematics course type), being retained to the next semester (i.e., sex, age, Pell status, and mathematics course type), and earning a GPA of 2.0 or higher (i.e., sex, age, race, Pell status, and mathematics course type), for students enrolled in both non-STEM and STEM mathematics corequisite courses at these institutions.

Chapter 1

Introduction

In the United States, the majority of students have been assessed as academically unprepared for college (Complete College America, 2012; Logue, Watanabe-Rose, & Douglas, 2016). These students must complete a course or series of developmental courses to remediate academic deficiencies, according to both two- and four-year college policies, “based on the purported theory that students need to pass the remedial courses to be able to pass the college-level courses” (Logue, Watanabe-Rose, & Douglas, 2016, p. 578). These required courses do not count toward graduation.

Of students who enroll in remedial courses, many do not complete them, and most do not persist to complete a college-level gateway course (i.e., a credit-bearing course that is a prerequisite to other required mathematics and English courses). According to a study of a cohort of students across the nation who entered college in 2006, at four-year colleges almost 75% of students completed the remedial courses; however, only 37% of those students went on to complete the associated college-level gateway course within two years (Complete College America, 2012, p.7).

According to Perin (2005), “Issues of effectiveness, organization, and instruction suggest that optimal models of developmental education remain to be identified” (p. 27). In recent years, however, a new strategy was developed to address gateway course completion rates: corequisite remediation, also known as corequisite support. With this strategy, support aligned to the gateway course content is delivered through an additional course or through a non-course option, such as a required time in a lab or with tutors.

Mathematics is the subject most often requiring remediation, according to Radford et al. (2012); thus, when institutions shifted to corequisite models, mathematics corequisite support became the most highly enrolled among the corequisite courses (as opposed to English or reading). This has proven true for West Virginia, a state whose public colleges and universities have been implementing corequisite support in lieu of remediation since 2015. According to the data obtained for this study, 74.6% of the students who enrolled in corequisite support courses in West Virginia from 2015 to 2020 enrolled in both mathematics and English, and 49% enrolled in a math corequisite only. In comparison, only 26% of students in this population enrolled in both math and English corequisite courses and only 25% enrolled in English corequisite only.

Further, in mathematics, many institutions have developed separate course pathways to most appropriately align with students' majors and career paths, referred to as mathematics pathways (Liston & Getz, 2019). The two dominant pathways in the field are science, technology, engineering, and mathematics (STEM) and non-STEM. STEM courses prepare students for college algebra, while non-STEM math courses are focused on preparation for liberal arts or other academic majors in which college algebra is not requisite. Corequisite courses are implemented in both pathways.

Although there have been studies conducted to show the effects of corequisite remediation on student success (Kashyap & Mathew, 2017; Logue et al., 2016), there has not been a large-scale study that examines the effects of corequisite support in mathematics on student success, particularly one that examines the differences between STEM versus non-STEM corequisite course success. This study focuses on the effectiveness of corequisite support in STEM and non-STEM mathematics on student success, as defined by course completion, retention to the next semester, and a grade point average (GPA) of over 2.0.

Preliminary Review of the Literature

In theory, traditional remediation -- structured to aid students through a series of non-credit bearing, foundational skill-building courses -- will increase success in first college-level math and English course(s) (Jaggars & Bickerstaff, 2018, p. 470). Research conducted to this point on the results of remediation, however, is varied. From demonstrating a performance advantage following remedial courses (Bettinger & Long, 2009; Moss, Yeaton, & Lloyd, 2014), to providing evidence of greater success when students skip remediation (Boatman, 2012; Calcagno & Long, 2008; Clotfelter, Ladd, Muschkin, & Vigdor, 2015; Jaggars, Hodara, Cho, & Xu, 2014; Martorell & McFarlin, 2011), to studies that have found mixed results (Melguizo, Bos, & Prather, 2011; Wolfle & Williams, 2014), there is no definitive conclusion on the effectiveness of remediation.

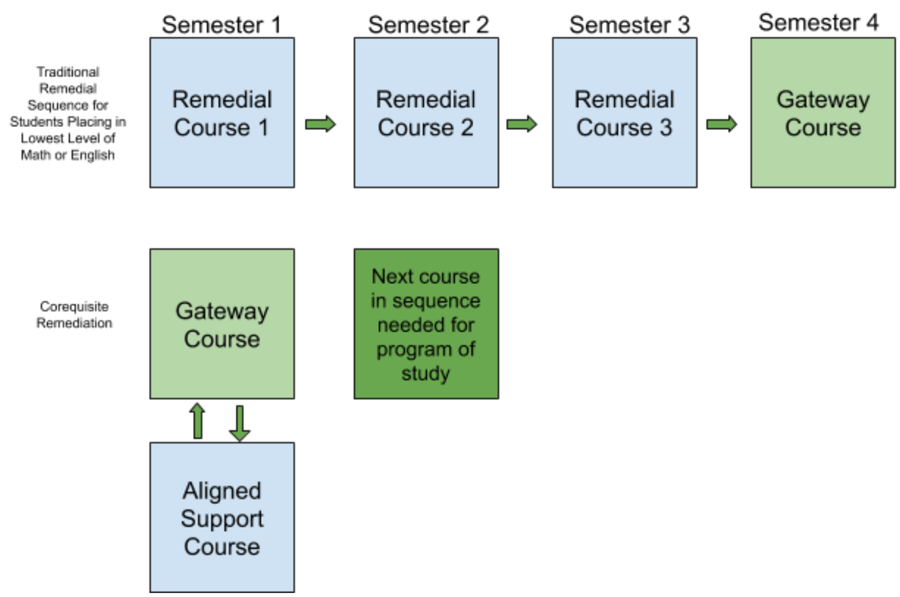
Because most of these studies focused on students who scored just above or just below the institutional or state-mandated "cut score" for placement into remediation, they call into question both the legitimacy of placement mechanisms and cut scores in addition to the efficacy of remedial courses. As discovered in Scott-Clayton and Rodriguez (2015) and Bailey, Jeong, and Cho (2010), these remedial screening tools have resulted in many more underrepresented students being assigned to developmental education and many students being under placed into developmental education, when there is a high probability that they could succeed in the college-level course(s). Further, research demonstrates that students assigned to a sequence of developmental courses rarely make it through the sequence to the college-level course (Bailey, Jeong, & Cho, 2010). Remediation, therefore, has largely failed to meet the goal of increasing student success in college-level courses.

Corequisite support places students directly into a college-level course with aligned academic support to eliminate developmental course sequences, as well as eliminate developmental content altogether. Supports can include just-in-time instruction, tutoring, and extra time on task that are connected to the material in the college-level course, thus eliminating long developmental sequences and the multiple student attrition points between remedial courses.

Vandal, Sugar, Johnson, and Zaback (2016) cited data from Tennessee, Indiana, Georgia, Colorado, and West Virginia that have scaled this strategy across institutions in their states and have reported dramatic increases in gateway course completion rates. Denley (2016), when studying corequisite remediation implementation in Tennessee public institutions, found that all students, regardless of their ACT scores, passed the gateway math course at higher rates in a shorter period when enrolled in corequisite support versus the traditional remediation model. Denley's report also revealed the similar gateway course completion rates for adult, low-income, and minority students enrolled in corequisite math courses.

Figure 1

Remedial Sequence versus Corequisite Support Sequence



Note. This figure illustrates the difference between the two sequences.

Denley's statewide analysis, as well as many studies which focused on only one institution (Beamer, 2021; Childers & Shi, 2021; Royer & Baker, 2018; Vestal, Brandenburger, & Furth; 2015), showed the pass rates of mathematics corequisite courses, in general, but did not examine differences in pass rates between STEM versus non-STEM pathways, Pell- and non-Pell eligible students (serving as a proxy for low socioeconomic status) or between sexes. These studies also declined to consider retention or semester grade point average after the course was completed.

Problem Statement

As evidenced above, the traditional approach to developmental education has proven unsuccessful in its aims to help students pass gateway courses and graduate with a certificate or a degree (Boatman, 2012; Calcagno & Long, 2008; Clotfelter, Ladd, Muschkin, & Vigdor, 2015;

Jaggars, Hodara, Cho, & Xu, 2014; Martorell & McFarlin, 2011). Corequisite support has been shown to increase the success of students, in terms of passing gateway courses and passing subsequent courses in the same subject (Denley, 2016; Kashyap & Mathew, 2017; Larance, 2019; Logue et al., 2016; Logue, Douglas, & Watanabe-Rose, 2019; Vandal, 2019; Vandal et al., 2016). Students across the country are enrolled in mathematics corequisite courses at high rates, as evidenced in West Virginia where in a five-year period, 12,516 students enrolled in these courses, both in STEM and non-STEM pathways. To further increase gateway course completion rates, retention, and overall student success, it was imperative to understand what, if any, differences existed between STEM and non-STEM corequisite course completion overall, as well as whether there were any demographic attributes associated with success rates among student populations.

Purpose of the Study

Although there have been studies conducted to show the effects of corequisite support on student success in gateway courses (Denley, 2016; Kashyap & Mathew, 2017; Logue et al., 2016; Logue, Douglas, & Watanabe-Rose; 2019), as well as many that have focused on a particular math course or courses at single institutions (Beamer, 2021; Childers & Shi, 2021; Royer & Baker, 2018; Vestal, Brandenburger, & Furth, 2015), there has not been a multi-institution, multi-year study that examines the effects of corequisite support in mathematics on student success, and none that examine the differences between STEM versus non-STEM corequisite course success. This study uses data from 2015-2020 from 18 public higher education institutions in West Virginia to examine the effects of corequisite support in STEM and non-STEM mathematics on student success, as defined by course completion, retention to the next semester, and a GPA of over 2.0.

Definition of Terms

For purposes of this study, the following definitions will apply.

- Corequisite support course – a supplementary course offered at the same time, or as a part of, a gateway course that offers additional support to students to achieve the outcomes in the gateway course
- Enrolling – registering for a course
- Gateway mathematics course – the first mathematics course a student takes that is credit-bearing and counts toward graduation requirements
- Non-STEM mathematics course - the courses that prepare students for a non-science, technology, engineering, or mathematics program of study, most often applied mathematics, quantitative reasoning, or statistics courses
- Passing - A student passed course if they received an A, B, C or P (Pass) grade in the gateway course. If the student received a D, F, W or Incomplete, they failed.
- Retention – student re-enrollment from semester to semester or year to year
- STEM mathematics course – the courses that prepare students for a science, technology, engineering, or mathematics program of study, most often college algebra or technical math courses

Research Questions

Institutions implement corequisite support in both STEM and non-STEM courses. This study aimed to answer the following questions about the effects of those courses on students who attend public higher education institutions in West Virginia:

1. To what extent do demographic or course attributes predict student success (i.e., passing a corequisite course, retention to the next semester, and a semester GPA of 2.0 or above) following the enrollment in corequisite courses in mathematics?
    a. To what extent is age a predictor of a student success?
    b. To what extent is sex a predictor of student success?
    c. To what extent is race a predictor of student success?
    d. To what extent is socioeconomic status (as measured by receipt of a Pell grant) a predictor of student success?
    e. To what extent is the type of math corequisite course (i.e., STEM or non-STEM) taken a predictor of success?
2. What are the differences in pass rates between students enrolled in STEM and non-STEM corequisite mathematics courses at public higher education institutions in West Virginia?
3. What are the differences in semester-to-semester retention rates between students who enrolled in STEM and non-STEM corequisite mathematics courses at public institutions in West Virginia?
4. What are the differences in students who earned a 2.0 or higher GPA between those who enrolled in STEM versus non-STEM corequisite mathematics courses at public institutions in West Virginia?

Methods

To determine completion rates in corequisite mathematics courses at public higher education institutions in West Virginia, the researcher requested student-level course completion data that included race, sex, age, and Pell grant status, from the 2015-2016, 2016-2017, 2018-2019, 2019-2020 academic years from the Policy and Planning Division of the West Virginia

Higher Education Policy Commission. Data were received in a secure manner in a web-based application. After cleaning the data to remove blank cells, each variable was coded as binary/dichotomous. A logistic regression was run to understand which, if any, student characteristics (i.e., sex, age, race, Pell status) were predictive of student success.

To understand the differences in pass rates, retention rates, and average GPA between STEM and non-STEM students, the researcher designed pivot tables and used descriptive statistics (i.e., Pearson Chi-Square) to determine overall differences and make comparisons among the student populations.

Sample

There are 12 public four-year and nine public two-year higher education institutions in West Virginia. Of those 21 institutions, two have never offered developmental education and do not offer corequisite support. One community college was not included in the data file. Thus, 18 West Virginia public higher education institutions are included in the study.

The sample included 16,543 individual student records across those 18 institutions and five academic years. While the dataset included students who also took English corequisites, this study focused on the 12,516 students who enrolled in a corequisite mathematics course.

Limitations

Limitations to this study are primarily those common to non-experimental research. First, the study has limited generalizability. West Virginia is a state with a racially and economically homogeneous population. According to the U.S. census, as of July 1, 2021, 93.1% of West Virginia's population was White, only 3.7% was Black or African American, and less than 1% of the population was Native American or Asian (U.S. Census Bureau, 2021). The median household income in the state was around $48,000 a year, with nearly 18% of the population living in poverty (U.S. Census Bureau, 2021). This majority White, low-income population limits the generalizability of this study, and cannot be used for more racially and ethnically diverse, more affluent states.

Second, among the limitations to the use of existing data is that those data were not originally collected to address the research questions in this particular study. Thus, some variables relevant to the study are not available because they were not collected or because they have been removed to protect the confidentiality of the sample or population. Further, the researcher could not guarantee equal sample sizes across groups, thus some groups have many more students than groups to which they are compared. The statistical analysis, however, controls for this issue.

In addition, the researcher who is analyzing the data did not collect it and is unaware of either the existence of or rationale for potential gaps, oversights, or omissions in the data collection process. These could possibly limit the explanatory power of interpretations based on the data. A close working relationship between the data provider and the researcher regarding the validity of the data, however, and clear and frequent communication concerning the researcher's request and needs have been employed to address and mitigate these potential problems.

Significance of the Study

The study has significance for administrators, faculty, and most importantly, students enrolled in gateway math courses with corequisite support who have been shown to succeed at higher rates (Beamer, 2021; Childers & Shi, 2021; Larance, 2019; Royer & Baker, 2018, Vandal, 2019; Vestal, Brandenburger, & Furth, 2015). This study identified differences in the success rates in STEM and non-STEM pathways, thus narrowing the focus from overall mathematics completion to pinpoint who, by subpopulation, was not successful. With this information, administrators and faculty in West Virginia can further refine the corequisite models in place to target additional support to the students who need it most. This study can also serve as a model for other states to use to examine their corequisite math courses by pathway and student population.

Further, previously published studies in this area concentrate on a small number of students in a single course in one academic semester; in contrast, this study examined over 10,000 students across 10 academic semesters, thus expanding its utility in the field.

Chapter 2

Review of the Literature

This study examined the effect(s) of corequisite mathematics courses, a strategy shown to improve gateway course completion rates when compared to the use of developmental education practices, on student success for specific subpopulations at public higher education institutions in West Virginia. The study adds to the current body of research on corequisite support courses, specifically demonstrating how STEM versus non-STEM corequisite mathematics courses effect student success, as defined as gateway mathematics course completion, retention to the next semester at the same institution, and a semester GPA of 2.0.

Review of Research

The literature review begins with a history of developmental education as a foundational element to understanding the corequisite support strategy. This section includes the initial purpose of developmental education, discusses how it is used at higher education institutions, and examines research findings about its efficacy.

The next section includes a review of the impetus for developmental education reform in the field, including research on course placement. This section also includes an overview of strategies with which institutions experimented as a solution to the challenges in developmental education course sequences before corequisite support was identified as a successful strategy.

The next section includes a review of the influential studies on corequisite support, both in English and mathematics. It includes multiple studies that focus specifically on corequisite support in mathematics and demonstrate the effectiveness of the strategy at increasing gateway course completion, when compared to developmental education courses. Finally, a study that defines different models of corequisite support is presented.

The next section discusses mathematics pathways and reviews the research supporting the course placement model to assign students to courses that best align with a major and career pathway. The researcher makes connections between corequisite support courses in mathematics and mathematics pathways.

Finally, the chapter details the history of corequisite support adoption and implementation in West Virginia and situates this study as integral to the body of research for continued student success in the state and across the country.

Developmental Education

For nearly 80 years, developmental education has been a traditional structure in higher education designed to address differing academic ability among students. The following section outlines its history and efficacy.

History

Differentiated academic ability and college preparedness have been seen as challenges for higher education since the mid 19th century, when universities instituted preparatory departments for core subjects like Latin, mathematics, and literature (Pearson Education, n.d.). Junior colleges were instituted in the early 20th century to prepare students for universities, resulting in a social categorization of those who attended these colleges as "lesser students" and increasing the elitism of four-year universities (Pearson Education, n.d.).

Developmental education became an embedded structure in higher education, particularly in open-access community colleges, after World War II when the 1944 G.I. Bill of Rights was signed by President Franklin D. Roosevelt (McCabe & Day, 1998; Perin, 2005). Further, the Civil Rights era resulted in an even greater increase in college-going rates, particularly among people of color. Increasing numbers of students with varied levels of skills and backgrounds presented a significant challenge to colleges and universities that were accustomed to educating a largely homogenous population of wealthy white males with similar academic preparation.

As a result, in the early 1970s, pre-college courses in reading, writing, and mathematics were developed in community colleges to support academically underprepared students (Perin, 2005, p. 27). Consistent with the original purpose of pre-college courses, students of color, poverty-affected students, and students over the age of 25 are still placed into remedial courses at a rate much higher than traditional-aged white students. Of all first- and second-year students at public, four-year institutions, around 29% are enrolled in remediation (Skomsvold, 2014); almost 40% of all first-year African American students are enrolled in remediation, 35% of students 25 years of age and older are placed into remediation, and 32% of low-income students are placed into remediation (Complete College America, 2012, p. 6).

In theory, traditional remediation is structured to aid students through a series of non-credit bearing, foundational skill-building courses to increase success in their first college-level mathematics and English courses (Jaggars & Bickerstaff, 2018, p. 470). In practice, however, research largely demonstrates that students rarely make it through the developmental sequence to the college-level course (Bailey, Jeong, & Cho, 2010). Research also shows that students who persist to the college-level course succeed at an equal rate to students who were directly placed into the college-level course (Boatman & Long, 2010).

In a research brief for the Center for the Analysis of Postsecondary Education, Rutschow and Mayer (2018) explored the breadth and scale of developmental education reforms across the United States. A national survey of over 1,000 open-access and nonselective postsecondary institutions was completed. The research brief did not contain a description of a method of analysis. Rutschow and Mayer found that 76% of public two-year colleges offered developmental education and used a traditional sequence of courses for at least three of their mathematics sections. For reading and writing, 53% of institutions deployed traditional remediation. This report showed the expansive nature of developmental education.

Effectiveness of Developmental Education

Boatman and Long (2010) examined the effects of remedial education with funding from the Institute of Education Sciences, U.S. Department of Education. The researchers conducted the study in collaboration with the National Center for Postsecondary Research.

The purpose of the study was to examine the effect of remedial courses on college students with different levels of academic preparedness, as assessed by ACT sub scores and/or the scores on a Computer Adaptive Placement and Assessment Support System (COMPASS) exam. Boatman and Long used enrollment information and transcript data from the Tennessee Higher Education Commission and the Tennessee Board of Regents for undergraduate students who started at any public two-year or four-year Tennessee institution in fall 2000 and who took a COMPASS mathematics, reading, or writing exam to conduct their empirical analyses. The study used a regression discontinuity design to examine the effects of remedial courses on students' credit accumulation, success in college-level courses, persistence from first to second year of college, and degree attainment.

The study found that students who are near the COMPASS "cut-score" and are placed into one remedial course experience the largest negative effects on college completion and credit accumulation. The researchers found, however, that students with lower levels of academic preparation than students near the "cut score" demonstrated smaller negative effects on credit accumulation, success in college-level courses, persistence from first to second year of college and degree attainment, and sometimes showed small positive effects from enrollment in remediation. Thus, the authors concluded the effect of remedial courses depends on the level of academic preparedness of the student.

This study was completed using Tennessee data and may not be generalizable across states. Federal, state, and institutional policymakers seeking to use these findings should first commission their own study of relevant data. Further, the researchers used a standardized test to determine placement, which has been revealed to be an inadequate predictor of student success (Bahr et al., 2019).

In contrast, Bailey, Jeong, and Cho (2010) examined student progression through sequences of remediation to identify patterns and determinants of success. The researchers used data from Achieving the Dream: Community College Count, a national initiative spanning multiple years that was constructed to increase student success at community colleges with large populations of students of color. The study included 256,672 students from 57 colleges; these students were first-time credential-seeking students who enrolled in fall 2003 to fall 2004.

The researchers accessed an Achieving the Dream database that housed information on “student gender, race/ethnicity, age at entry, full- or part-time enrollment, major, all remedial courses taken, and the grades earned in those courses” (p. 258). The data also contained a variable indicating whether “students were referred to developmental education and, for those who were referred, the level to which they were referred” (p.258).

The study lacked a thorough description of method, although from the tables included in the report, it can be inferred that descriptive analyses were completed. The analyses showed that most students never enroll in the remedial courses to which they are assigned, fail a course in which they have enrolled, or drop out of college. Less than 50% of students completed developmental sequences, and only 20% of those referred to mathematics remediation and 40%

of those referred to reading remediation completed a college-level course within three years of enrollment. More specifically, men, students over the age of 25, Black students, students who attended college part-time, and students in vocational programs were less likely to progress through a full developmental sequence.

Black and Hispanic students, as well as older students, are enrolled in Achieving the Dream colleges at a significantly higher rate than at a national sample of community colleges. The comparison demonstrates the Achieving the Dream initiative's emphasis on serving underrepresented populations; however, it limits the generalizability of the study's findings.

The researchers concluded that without additional information on students, including their motivations for attending college, they could not infer reasons for student attrition. Yet, they stated that success of students placed into remediation has implications for meeting attainment goals, bolstering the economy, and decreasing or eliminating equity gaps. Students with academic needs should not be placed onto an alternative educational path, but instead placed into a typical academic experience and provided supports.

Scott-Clayton and Rodriguez (2015) examined data from 100,000 first-time, degree-seeking students enrolled in one of six institutions in a large urban community college system between fall 2001 and fall 2007 to add to the body of research that explores the challenges with the traditional developmental education system. The researchers employed a regression discontinuity (RD) design to investigate under-researched outcomes and review the effect of remedial assignment on students. The RD design compared students who scored just above and just below the pre-determined cut-score that controls remedial placement.

Scott-Clayton and Rodriguez (2015) developed a conceptual framework to analyze the functions of developmental education by identifying three non-mutually exclusive models:

> Remediation as *skill development* that prepares students for future college-level courses, as *discouragement* that stigmatizes students and sends a signal about their probability of college success, and finally as a *diversion* that steers students out of college-level courses and reduces heterogeneity within classrooms. (p. 4)

The community college system provided the data for the study and included COMPASS scores for students who enrolled and those who did not, as well as accumulated credits, grades, degree outcomes for students who remained enrolled. Researchers used the RD design to identify the causal effect of remedial assignment for students who are assessed just above or just below the cutoff. They also assigned students to groups of high, medium, and low academic risk of students who scored need the cutoff. The researchers found that, overall, around 90% of test-takers were assigned to remediation in one or more subjects, with 72% assigned to developmental mathematics, 72% to developmental writing, and 38% to developmental reading.

The researchers identified the primary function of remediation to be diversionary, as students were shown to enroll in remediation courses and persist at the same rates as students who enroll in college-level courses. As demonstrated in Bailey, Jeong, and Cho (2010), the difference is that students who are enrolled in remediation must pass a sequence of courses before ever entering a college-level course. In fact, the study found that students enrolled in mathematics remediation were five percentage points less likely to pass college-level mathematics, which is a percentage of the students who persisted through the sequence to get to the college-level course. Using this information, the researchers extrapolated that potentially 25% of students placed into developmental mathematics and up to 70% placed in developmental reading would have earned a B or better in the associated college-level course.

The researchers concluded that remediation does not develop academic skills that sufficiently increase rates of college success. The researchers also determined that developmental courses in the diversionary function do not provide content that prepares students for college-level work. In addition, Scott-Clayton and Rodriguez suggested that policymakers should pay attention to the perils of mis-assigning students to remediation, particularly if the primary function is diversionary and not skill development.

Impetus for Reform

While more and more studies on developmental education continued to show mixed outcomes, as evidenced above, others in the field were beginning to further examine placement methods and other methods of supporting students in gateway courses. This section includes research that led the field to consider corequisite support as the key reform to increase gateway course success.

Placement into Developmental Education

Scott-Clayton, Crosta, and Belfield (2014) began to explore the efficacy and accuracy of remedial screening tools. As discovered in Scott-Clayton and Rodriguez (2015) and Bailey, Jeong, and Cho (2010), these tools have resulted in many more underrepresented students being assigned to remediation and many students being mis-assigned. In Scott-Clayton, Crosta, and Belfield's 2014 study, the researchers sought to understand the prevalence of mis-assignment using cutoff scores from commonly used placement tools and whether these tools have a disparate effect by race or sex. The study also examined high school transcript information as a tool for placement. The researchers evaluated the trade-offs of assigning too many or too few students to remediation.

To answer the research questions, the authors used high school transcript data, remedial test scores, and the colleges grade of tens of thousands of students in two large community college systems. One large, urban community colleges system contributed data from four cohorts, totaling 70,000 first-time students. Data were also gathered from two cohorts of first-time degree-seeking students enrolled at a statewide community college system, adding 49,000 more students to the study. To answer the research questions, the researchers analyzed a mix of administrative data, including high school transcripts, remedial test scores, and college grades in a predictive model. Specifically, a loss function called the severe error rate (SER) was used to combine the proportion of students predicted to earn a B or better in a college-level course and placed into a developmental course with the proportion of students enrolled in a college-level course and predicted to failed there.

The researchers described multiple findings: 25% of test-takers in mathematics and 35% in English were mis-assigned, with severe under-placements in remedial courses. High school transcript data were more predictive of success and could significantly reduce the prevalence of screening errors. Further, the findings showed that the choice of placement tool has strong negative implications for the race and sex composition of college-level and remedial courses. The authors suggested that institutions that rely on high school transcript information could remediate substantially fewer students without affecting the success rate in college-level courses. This study has implications for faculty who must consider that misplacement in developmental courses could cause a higher dropout rate.

Di Xu (2016) sought to examine the academic outcomes of students placed into differing levels of reading and writing developmental education, as most prior studies examined only the outcomes of students who placed near the placement cut score. The researcher used data from the

Virginia Community College system to do the analysis. The study used a regression discontinuity design to examine causal effects of enrollment in developmental reading and writing on short- and long-term outcomes.

The short-term outcomes examined were first-year dropout and probability of enrollment and success in the first college-level English course. Xu (2016) also reviewed the total, within five years of any types of credits, of number of college credits earned, and whether a student earned any credential or transferred to a four-year school. The author concluded that students who enrolled in developmental courses may naturally spend more time at the institution and earn more credits, due to the nature of developmental sequences; therefore, the credit accumulation and time-to-degree metrics may have been unreliable.

The findings showed that lower-level developmental course work in both subjects showed a significant negative impact on first-year retention rates, as taking lower-level reading increases the probability of dropout sometime in the first year by 13 percentage points. Further, taking a lower-level writing course increases dropout within the first year by 19 percentage points. Time to degree and credit accumulation were both lower for students enrolled in the lower-level reading and writing courses and the probability of earning a credential or transferring to a university was 14 percentage points lower for students in lower-level developmental sequences. Xu (2016) posited that the low credit accumulation, time to degree, and completion/transfer outcomes were due to the high probability of dropout.

Most notably, these outcomes were more significant for women, younger students, and Black students. This study had implications for policymakers who can mandate shorter or no developmental courses. First, Xu (2016) noted, policymakers must consider that the “economic, psychological, and academic burdens imposed by these lengthy developmental sequences might in fact outweigh their intended benefits" (p. 504). Further, the researcher suggested that because the Virginia study's results differ from Boatman and Long's (2010) results in Tennessee, it is imperative for each state to do their own research on developmental outcomes. Finally, Xu (2016) reviewed the equity imperative, as the strongest negative effects of long developmental sequences were on Black students.

Xu (2016) noted that Virginia began to undertake developmental education reform in 2013. Around this time, developmental reforms were beginning to emerge across the country.

Varied Strategies to Address Developmental Education Outcomes

In the book *13 Ideas that are Transforming the Community College World,* the chapter entitled "Recognition, Reform, and Convergence in Developmental Education" outlined higher education's movement away from developmental education and toward corequisite support (Vandal, 2019). According to Vandal (2019), two initiatives emerged around 2012 that were aimed at accelerating students through developmental education course sequences: the Developmental Education Initiative, developed by MDC and Achieving the Dream, and the Developmental Studies Redesign Initiative by the Tennessee Board of Regents. These initiatives focused on providing support to students in only the exact competencies identified, creating modules for students to complete at a faster rate than normal developmental course sequences.

During this time, computer-based products to help with this competency modularization began to proliferate at institutions across the country. These programs, however, did not solve the problem of student attrition (Bickerstaff, Faye, & Trimble, 2016). As an effort to mitigate the attrition issue, Carnegie Foundation for the Advancement of Teaching and Learning, the Charles A. Dana Center at the University of Texas at Austin, and the California Acceleration Project developed models that limited developmental courses to one semester (Vandal, 2019). Results from these reforms were promising and multiple studies showed increased gateway course success, in mathematics, writing, and reading alike (Hayward & Willet, 2014; Hoang, Huang, Sulcer, & Yesilyurt, 2017; Rutschow & Mayer, 2018).

Some reform efforts, however, focused on eliminating the attrition points and instead placing students directly into a college-level course while aligning support to that course. Vandal (2019) discussed two reform efforts from which corequisite support emerged: the Community College of Baltimore County's Accelerated Learning Program (ALP) in English and the Structured Learning Assistance (SLA) model at Austin Peay State University for mathematics. Students in these programs were achieving triple the gateway course success rates than students placed into traditional developmental education sequences (Cho et al., 2012; Griffy, n.d.). These corequisite models, championed by national organizations like Complete College America, began to proliferate across the nation's higher education institutions.

Corequisite Support

Small pilots of corequisite support at institutions like the Community College of Baltimore County (CCBC) and Austin Peay State University showed such promising success that researchers began to take interest. Researchers at the Community College Research Center (CCRC) began to study the effects of the ALP model of corequisite support at CCBC, while others began to study models of mathematics corequisite support at other institutions. This section will discuss the research on corequisite support in both English and mathematics, as well as define differing models.

Accelerated Learning Program Research

Jenkins, Speroni, Belfield, Jaggars, and Edgecomb (2010), researchers at CCRC, studied the effectiveness and cost of the Accelerated Learning Program (ALP). The work was funded by the Lumina Foundation and in partnership with Achieving the Dream. The study used multiple statistical analyses to determine the effects of participating in ALP on a series of student outcomes: ENG101 and ENG102 completion, college persistence, and passing other college-level courses. The findings suggested that participation in ALP results in higher ENG101 and ENG102 completion rates. There was no evidence of increased persistence or an increase in the pass rates in other college-level courses.

To examine cost, the researchers used a questionnaire to determine costs associated with ENG052 and ENG101. Based on a typical course-taking pathway of 250 students, the researchers analyzed the cost-effectiveness of ALP versus the traditional remedial sequence. Based on the number of courses students take, the researchers found that students who took the traditional remediation sequence passed 1.79 fewer courses than ALP students. Due to the increased course enrollment and completion of ALP students, ALP was substantially more cost-effective.

In 2012, Cho, Kopko, Jenkins, and Jaggers of the Community College Research Center, presented findings from a follow-up analysis of the Accelerated Learning Program (ALP) at the Community College of Baltimore County (CCBC). The purpose of the study was to examine the effect of students' ALP participation on English 101 and English 102 completion, as well as determine the effect of ALP on student year-to-year persistence, using updated information provided by CCBC. The researchers also studied the effect of ALP on students of color and those from low-income backgrounds, whether continuous improvement of the ALP model affected student outcomes and sought to determine the effects of a mixed cohort design.

The researchers used unit-record data and transcript information from CCBC to complete the analysis. The student population included those who were enrolled in ENGL052, the highest level developmental English course at CCBC, for the first time from fall 2007 to fall 2010, including summer terms. This included 592 students enrolled in ENG101 and its companion ALP course, as well as 5,545 students who took ENG101, but were not enrolled in the companion ALP course.

Using descriptive and regression analyses, the researchers found that students who participate in ALP had substantially better rates of ENG101 and ENG102 completion. Further, ALP students were more likely to persist to the next year. The researchers used propensity score matching to account for the issue of dissimilar comparison groups and the statistically significant findings showed that ALP students were more likely to complete ENG101 and ENG102, as well as more likely to persist to the next year and complete more college credits than the non-ALP students.

ALP student outcomes increased slightly in more recent cohorts. Student of color and from low-income backgrounds showed increased outcomes, although white students and students from high-income backgrounds also showed strong increased outcomes, thus mitigating the impact on equity gaps. The results demonstrated the effectiveness of the ALP model.

Coleman (2015) studied the ALP model in her role as the Director of the Center for Applied Research. The report was funded by the Kresge Foundation and prepared in collaboration with the student success organization Achieving the Dream. The study aimed to determine the extent to which the Accelerated Learning Program was being implemented across the United States. The study also examined fidelity in implementation to the original ALP model.

Coleman surveyed 137 colleges in the first phase of the study, then in the second phase, followed up with four colleges to examine student record data. The survey asked about institutional characteristics, including descriptions of the developmental writing program and the institution's version of the ALP model. From the survey, Coleman categorized the institutions ALP model into three distinct implementation models: Community College of Baltimore County ALP model, the triangle model, and other. The researcher did not include a description of method for analysis of the survey of 137 colleges or a method of analysis of student data from the four colleges. The study found that ALP was being implemented in different ways across the country. All colleges in the study that were implementing ALP, in any format, showed improved student outcomes.

Corequisite Mathematics Research

Though the bulk of research being done at this time was focused on the ALP model, other models of corequisite support began to emerge, specifically in mathematics. Boatman (2012) studied causal effects on student's early academic success in redesigned developmental mathematics courses in Tennessee. This research was supported by the American Education Research Association and published by the National Center for Postsecondary Research. Boatman (2012) used a regression discontinuity design to estimate the causal effects of mathematics remediation courses and redesigned mathematics courses on student's subsequent academic outcomes, including early persistence and cumulative credits and college-level credit accumulation.

The study found that students in both mathematics remediation and mathematics redesigned courses enrolled and persisted at the same rate in the second year but took more college-level courses because of the redesign process. Boatman (2012) also found that students who enrolled in the redesigned mathematics courses had more positive outcomes than did their peers in non-redesigned courses during the same timeframe. Students who took the redesigned courses at Austin Peay State University who used the Structured Learning Assistance model referenced above and those at Cleveland State Community College benefited most from the redesigned courses.

Logue, Watanabe-Rose, and Douglas, researchers at the City University of New York (CUNY), studied the effects of mainstreaming students into college-level mathematics by conducting a randomized controlled trial, with support from the Spencer Foundation and by CUNY, in 2016. The study included 907 college students from the three community colleges in the CUNY system who were then randomly placed into elementary algebra, elementary algebra with a workshop, or statistics with a workshop. The researchers referred to the courses with the workshop portions as mainstreaming, but in a follow up study they refer to these courses as corequisite remediation.

To analyze the treatment effects, the researchers used intent-to-treat and treatment-on-compliers analyses. The statistically significant findings show that students who were assigned to Statistics with a workshop passed at a rate that was 16 percentage points higher than those assigned to Elementary Algebra and 13 percentage points higher than those assigned to Elementary Algebra with a workshop. There was no significant difference in student outcomes between the two Elementary Algebra courses.

Further, one year out from the Statistics-with-workshop course, the statistics students subsequently accumulated more credits than those who were assigned to the Elementary Algebra courses. The researchers recommended policies that allow students to take college-level courses in lieu of remedial courses to increase student outcomes.

Logue, Douglas, and Watanabe-Rose (2019) extended their study to show results over time and in different contexts. The CUNY researchers continued to examine the performance of students engaged in the 2016 randomized controlled trial over a three-year period. In this article, as stated above, the authors did not use the term "mainstreaming" as in their first article and instead used "corequisite remediation" to describe the model of college-level courses with additional academic support. Data from the National Student Clearinghouse on progression, course enrollment, and graduation were used to examine student success. The researchers performed a logistic regression analysis.

The study found that students enrolled in corequisite remediation showed significantly higher mathematics course pass rates, showed success in other disciplines, and had significantly higher graduation rates. The researchers used propensity score matching to demonstrate students across the CUNY system had higher success rates in college-level statistics and quantitative reasoning courses with corequisite remediation than students who took traditional remedial elementary algebra.

Researchers concluded that corequisite remediation is successful across a variety of settings and over time. Policies that require that students be directly placed into college-level mathematics with corequisite remediation increased student success and helped to shrink equity gaps, due to the disproportionate number of students of color and those from low-income backgrounds who were placed in remedial sequences. Direct placement into a college-level course mitigated the inequality in placement mechanisms.

Boatman (2021) examined effects of three types of institutional reform efforts related to mathematics: acceleration, modularization, and corequisite mathematics on students short-, mid-, and long-term academic success. In the study, the short-term outcome was performance in college-level mathematics, the mid-term outcome was credit accumulation, and the long-term outcome was persistence to degree.

Using data from four cohorts of students enrolled at any of the institutions affiliated with the Tennessee Higher Education Commission (THEC) and the Tennessee Board of Regents (TBR), the researcher used three analytical methods: Regression Discontinuity (RD) across colleges, post-design, RD within redesign colleges, pre- and post-design, and differences within and across colleges, pre-and post-design. Findings showed that students enrolled in acceleration redesign and mathematics corequisite courses had more positive outcomes than their peers. Modularization courses did not show this effect.

At the time of the publication, the researcher worked at the Lynch School of Education and Human Development at Boston College and had completed numerous studies on developmental education and mathematics course redesign. This peer-reviewed article was more comprehensive than most, considering multiple years of data, as well as multiple institutions. While it did examine mathematics corequisites, it did not examine STEM and non-STEM courses or closely examine student characteristics as predictors of success.

Defined Models

Daugherty, Gomez, Carew, Mendoza-Graf, and Miller (2018), researchers from the RAND Corporation, a policy and research firm, explored the design and implementation of corequisite models in Texas community colleges to identify challenges and provide information about overcoming those challenges. The study was funded by the U.S. Department of Education. The researchers completed a randomized control trial of five community colleges and used a statewide implementation survey which included 55 institutions.

The report does not include a description of methods; it does, however, discuss findings from the study. The researchers identified five common models of corequisites: paired course, extended instructional time, ALP, academic support service, and technology-mediated support.

The study also outlined challenges with corequisite implementation: limited buy-in, issues with scheduling and advising, limited preparation and support, and rapid speed of state policymaking. The report included myriad solutions for these challenges. The researchers concluded that while many models of corequisite were being implemented and showing success, institutional context may have influenced the success rates. Continuous improvement of corequisite models was deemed an imperative.

Mathematics Pathways

Alongside the developmental education reform movement, the field of mathematics recognized the high rate at which students were failing college algebra, as it was the default mathematics course for most students across the nation (Vandal, 2019). In 2015, the American Mathematical Association of Two-Year Colleges (AMATYC), the American Mathematical Society (AMS), the American Statistical Association (ASA), the Mathematical Association of America (MAA), and the Society for Industrial and Applied Mathematics (SIAM) created guidance for the field in the jointly released, *A Common Vision for Undergraduate Mathematical Sciences Programs in 2025*, authored by Karen Saxe and Linda Braddy.

These prominent mathematics associations agreed that curricular shifts were necessary to increase student success in mathematics and stated, “The mathematical sciences community must begin to think in terms of a broader range of entry-level courses and pathways into and through curricula for all students, including mathematics and other STEM majors as well as non-STEM majors” (Saxe & Braddy, 2015). This paper also outlined the need to include statistics, modeling, and computation as gateway math content (Saxe & Braddy, 2015), offering non-STEM pathways that better align to majors and careers.

With the backing of the major associations on the importance of mathematics pathways, organizations like the Charles A. Dana Center (Dana Center) at the University of Texas at Austin, founded by world-renowned mathematician Uri Treisman, and Complete College America began to assist institutions with implementation of both mathematics pathways and corequisite support. The Dana Center worked with more than 30 states to help institutions implement mathematics pathways and corequisite support, featuring a model of mathematics pathways that demonstrates the inextricable link to corequisite support, as their four guiding principles are (Charles A. Dana Center, 2022):

1. All students, regardless of college readiness, enter directly into mathematics pathways aligned to their program of study.
2. Students complete their first college-level math requirement in their first year of college.
3. Strategies to support students as learners are integrated into courses and are aligned across the institution.
4. Instruction incorporates evidence-based curriculum and pedagogy.

Mathematics Pathways and Corequisite Support

Mathematics pathways and corequisite support are considered complementary strategies. Results from research on the combination of mathematics pathways and corequisite support demonstrate an increase in gateway course completion, as shown in the following two studies.

Carnegie Math Pathways, according to Savcak and Klipple (2022), created specific corequisite programs for students to accelerate them through the gateway course and provide alternative pathways to algebra: Quantway and Statway (p. 5). These programs have been adopted nationwide and have served over 80,000 students. Results from an internal study completed by Carnegie Math Pathways showed that in academic year 2017-2018, 21% students passed gateway quantitative reasoning without any type of support; in contract, those enrolled in the Quantway corequisite course passed at rate of 75% in 2020-2021, an increase of 54 percentage points (Savcak & Klipple, 2022). In statistics, there was a 15% baseline of students passing the gateway statistics course. Now, with implementation of Statway corequisite, 61% are passing the gateway statistics course (p. 6).

This work and the subsequent report reviewed here were funded by numerous foundations, including the Bill & Melinda Gates Foundation, the Lumina Foundation, the Kresge Foundation, the Carnegie Corporation of New York, Ascendium Education Group, the ECMC Foundation, and the National Science Foundation. No methods are detailed in this study, and it was completed by researchers internal to the organization which published it.

Childers and Shi (2021) examined corequisite support in quantitative reasoning and mathematical reasoning (QMR) for non-STEM majors and college algebra for STEM majors. The research question in this study was, "How does modifying student placement effect co-requisite course pass rates?" (p. 5). The researchers compared the outcomes of those enrolled in foundations courses, which require a full semester of mathematics remediation to prepare for college-level math, to those enrolled in corequisite courses using descriptive statistics to calculate pass rate.

The results showed that students who took the foundations courses in both QRM and college algebra passed at a lower rate than those who took the corequisite courses. While the QRM corequisite students achieved the same or a slightly better passing rate than those in the foundations course, students passed the college algebra corequisite at a rate of 15.4% higher than those in the foundations course. Researchers recommended expanding the placement range to increase the number of students permitted to take the corequisite courses or eliminating the foundations courses altogether.

This study was completed at a midsize, public 4-year institution in the southern United States that has been implementing some form of corequisite support since summer 2016. This limits the generalizability of this study.

Corequisite Support in West Virginia

In 2011, almost all the West Virginia's institutions offered non-credit bearing developmental education. Data collected by the West Virginia Higher Education Policy Commission at that same time showed that as few as 13% of students enrolled in developmental mathematics courses went on to pass a college-level mathematics class in the first two years of enrollment at certain institutions, and the systemwide pass rate for college-level mathematics in the first two years of enrollment was around 37% (C. Dennison, personal communication, March 2, 2021) These rates spurred the West Virginia Higher Education Policy Commission (Commission) to action. According to Corley Dennison, Vice Chancellor for Academic Affairs at the Commission (personal communication, March 2, 2021), the statewide governing body began to issue grants to institutions willing to pilot corequisite support implementation.

Timeline of Reform

In August of 2013, the Chancellor of the West Virginia Community and Technical College System (CTCS) issued guidance to all community colleges in the state that all two-year institutions must fully adopt the corequisite model by the fall of 2014 (C. Dennison, personal communication, March 2, 2021). This guidance was followed by a few years of intensive technical assistance to support mathematics and English faculty with implementation of corequisite support.

In 2016, West Virginia updated the Commission policy, Title 133 Freshman Assessment and Placement Standards, to read “students not meeting placement standards into college-level mathematics or English must be placed into college-level, credit-bearing courses with required academic support” and since then, has been further updated to read, “full or part-time students identified as requiring remediation must enroll in the required co-requisite courses or other entry-level college courses with supplementary academic support in the first year of enrollment (WV§133-21, 2019). This policy update supported the Commission’s goal that by Fall 2019, all students who require academic support would be placed into corequisite support at both two-year and four-year institutions.

According to Dennison (personal communication, March 2, 2021), this goal has been broadly met, with the systemwide pass rate for gateway mathematics increasing by 39% and the gateway English pass rate increasing by 16.4% since 2014. Some institutions are greatly exceeding expectations; the college-level English pass rate at one four-year institution is at 92% and another four-year institution has increased pass rates from 37% to 83% across gateway courses (personal communication, March 2, 2021).

Corequisite Support Research in West Virginia

Campbell and Cola (2020), with financial support from the Commission, examined the return on investment of corequisite support implementation in West Virginia. The researchers used a mixed method design, disseminating a survey to institutions in West Virginia to understand the financial implications of implementation of corequisite support and analyzing extant data from the Commission. The study examined elements like cost to design the support, cost per student, changes to full-time equivalency for faculty, and the estimated cost to retain a student, using a dataset of 36,000 students.

The research found the implementation of corequisite support is cost-neutral, with the gains in retention more than compensating for the initial cost of implementation and the prolonged shift in instructional method(s). The study also found that corequisite support is effective across multiple demographic groups, including race and ethnicity, age, income-status, and sex; however, the study did not examine only mathematics or compare STEM versus non-STEM mathematics courses.

Mathematics Pathways in West Virginia

There has not been a statewide reform effort around mathematics pathways in West Virginia; however, in the data provided for this study, there were both STEM and non-STEM corequisite courses offered at all included institutions. Institutions may have created mathematics pathways without notifying the Commission and Council.

Conclusion

The literature described offers a solid foundation on which to build further research. While there are myriad studies on the effects of corequisite mathematics courses on gateway course completion, none clearly examine the effects of the mathematics pathway students enroll in or consider student characteristics as predictors of success. This study will close those gaps by examining the effect of corequisite mathematics courses on student success for specific subpopulations at public higher education institutions in West Virginia. The study adds to the current body of research on corequisite support courses, specifically demonstrating how STEM versus non-STEM corequisite mathematics courses effect student success, as defined as gateway mathematics course completion, retention to the next semester at the same institution, and a semester GPA of 2.0 or higher.

Chapter 3

Methods

Corequisite support has been shown to increase gateway course success rates and retention rates among all students, particularly among Black and Latinx students and those who are Pell-eligible; however, gaps still exist in completion rates by race, socioeconomic status, age, and sex (Denley, 2016; Idrissi, Cuellar, & Funk, 2018; Kashyap & Mathew, 2017; Larance, 2019; Logue et al., 2016; Logue, Douglas, & Watanabe-Rose, 2019; Vandal, 2019; Vandal & Todd, 2020; Vandal et al., 2016). Further, it is not understood the extent to which student characteristics of those enrolled in mathematics corequisite courses, both STEM and non-STEM, predict academic success.

Institutions implement corequisite support in both STEM and non-STEM courses. This study aimed to answer the following questions about the effects of those courses on students who attend public higher education institutions in West Virginia:

1. To what extent do demographic or course attributes predict student success (i.e., passing a corequisite course, retention to the next semester, and a semester GPA of 2.0 or above) following the enrollment in corequisite courses in mathematics?
    a. To what extent is age a predictor of a student success?
    b. To what extent is sex a predictor of student success?
    c. To what extent is race a predictor of student success?
    d. To what extent is socioeconomic status (as measured by receipt of a Pell grant) a predictor of student success?
    e. To what extent is the type of math corequisite course (i.e., STEM or non-STEM) taken a predictor of success?

2. What are the differences in pass rates between students enrolled in STEM and non-STEM corequisite mathematics courses at public higher education institutions in West Virginia?
3. What are the differences in semester-to-semester retention rates between students who enrolled in STEM and non-STEM corequisite mathematics courses at public institutions in West Virginia?
4. What are the differences in students who earned a 2.0 or higher GPA between those who enrolled in STEM versus non-STEM corequisite mathematics courses at public institutions in West Virginia?

This chapter describes the research design, selected population, data collection process, and data analysis used to answer the research questions and reveal topics for further inquiry.

Research Design

In this study, the researcher uses a nonexperimental, quantitative research design to answer the research questions. Extant, student-level data were requested from the West Virginia Higher Education Policy Commission's Division of Policy and Planning. These data included: mathematics gateway course completion for students enrolled in corequisite mathematics, retention to the next semester, and grade point average following completion of the corequisite mathematics course over five academic years (i.e., 2015-2016, 2016-2017, 2017-2018, 2018, 2019, and 2019-2020).

Population

West Virginia has 12 public four-year and nine public two-year higher education institutions, serving over 97,000 students in academic year 2018-2019 (West Virginia Higher Education Policy Commission, 2020). In the fall of 2019, of those more than 97,000 students, 13,321 were first-time freshmen (Treadway, 2020a; Treadway, 2020b).

Of the 21 institutions, two have never offered developmental education courses and thus, have not and will not offer corequisite support, and one institution did not report data to the Commission. Eighteen public higher education institutions were thus included in the study (Appendix B). The dataset included 16,543 students across these institutions. Of these students, not all enrolled in only corequisite mathematics. Table 1 shows the courses in which these students enrolled.

Table 1

Corequisite Course Enrollment from 2015-2020

Type of Course enrollment	Number of Students	Percentage of Students
Both corequisite math and English	4,242	26%
Corequisite English only	4,118	25%
Corequisite math only	8183	49%
Total	16,543	100%

This study focused on the 12,516 students who enrolled in corequisite mathematics courses over five academic years.

Data Collection

The extant data for this study were requested from the West Virginia Higher Education Policy Commission (Commission) and the West Virginia Council for Community and Technical College Education (Council) data warehouse. Each public institution in the state is required to submit certain data to the Office of Policy and Planning at the Commission, and the Commission has a structured process through which researchers may request the data from the warehouse. Researchers must meet all outlined requirements for privacy, confidentiality, and security. Table 2 provides an overview of the data elements the researcher requested from the Commission for students across the five academic years identified. The data disclosure agreement between the research and the Commission and Council can be found in Appendix B.

Table 2

Data Elements Requested Across Academic Years by Institution

Student-level data elements	Student characteristics
Corequisite course prefix	Sex
Corequisite course number	Age
Corequisite mathematics enrollment	Race/ethnicity
Corequisite mathematics completion	Pell grant recipient status
Corequisite mathematics final grade	
Retention to next semester	
GPA after completion of corequisite courses	

The Commission and Council were unable to provide all requested data elements and were unable to disaggregate the student characteristic data to fine detail. Age, thus, was rendered as traditional (i.e., under 24) and non-traditional (i.e., 24 and older); and race/ethnicity were reported as minority and non-minority, with non-minority indicating the student is White and minority indicating the student is of any other race or ethnicity. Some students were coded in the race variable as “other,” so the researcher re-coded these as “minority” to create a dichotomous variable for analysis. Forty of the records had blank responses for the demographic categories, and thus, were not included in the analysis.

Data Analysis

The researcher first isolated the records for students enrolled in mathematics corequisites from the dataset. Once isolated, using the institution name, along with the course prefixes and numbers, mathematics course descriptions were found in online course catalogs (see Appendix B). The researcher coded each course as STEM or non-STEM, based on the course descriptions.

After cleaning the data to remove blank cells, each variable was coded as binary/dichotomous. A series of logistic regressions were run to understand which, if any, student characteristics (i.e., sex, age, race, Pell status) were predictive of student success.

To understand the differences in pass rates, retention rates, and average GPA between STEM and non-STEM students, the researcher designed pivot tables and used descriptive statistics (i.e., Pearson Chi-Square) to determine overall differences.

Limitations

Institutions in West Virginia are required to submit data to the Commission and Council. Data are exported from the institutional student information systems and flaws in the data entry, export, and submission could be present. The Commission and Council, however, have developed a way to flag corequisites in the student information system to reduce error and increase usability of the data. Also, while the researcher used field-recognized definitions for STEM and non-STEM courses, she used her professional judgment to code the course descriptions as STEM and non-STEM.

Further, among the limitations to the use of existing data is that those data were not originally collected to address the research questions outlined in this study. Consequently, some variables relevant to the study may be unavailable because they were not collected or because they have been removed to protect the confidentiality of the population. In addition, the researcher did not collect the data and is potentially unaware of gaps, oversights or omissions in the data collection process which could possibly limit the explanatory power of interpretations based on the dataset. A close working relationship between the data provider and the researcher regarding the validity of the data and clear and frequent communication concerning the researcher's request and needs were employed to address and mitigate these potential problems. Further, the researcher could not guarantee equal sample sizes across groups, thus some groups have many more students than groups to which they are compared. The statistical analysis, however, controls for this issue.

In addition, the data are limited to West Virginia. This impedes generalizability of the study's results to other states with differing student populations, higher education governance structures and policies, and/or central data collection models.

Finally, while the researcher's professional experience as a higher education consultant who works directly with institutions implementing corequisite support and mathematics pathways may constitute a source of empathy and provide an experiential background that enhances effectiveness in eliciting and understanding the extant data and the resulting analyses, it may also be viewed as a limitation in that it is a potential source of bias.

Chapter 4

Findings

Corequisite support has been shown to increase the success of students, in terms of passing gateway courses and passing subsequent courses in the same subject (Denley, 2016; Kashyap & Mathew, 2017; Larance, 2019; Logue et al., 2016; Logue, Douglas, & Watanabe-Rose, 2019; Vandal, 2019; Vandal et al., 2016). A number of those students enroll in STEM and non-STEM mathematics corequisite courses in particular, as is demonstrated in West Virginia where in a five-year period, 12,516 students enrolled in these courses.

In this study, the researcher aimed to understand what differences, if any, exist between STEM and non-STEM corequisite course completion, as well as whether there are any demographic or course attributes associated with student success. Success measures selected for this study were 1) passing the corequisite mathematics course, 2) retention to the next semester at the same institution, and 3) earning a GPA of 2.0 or higher – metrics which are typical leading indicators of student success in the postsecondary field. In particular, this study aimed to answer the following questions about the effects of corequisite support courses on students who attend public higher education institutions in West Virginia.

1. To what extent do demographic or course attributes predict student success (i.e., passing a corequisite course, retention to the next semester, and a semester GPA of 2.0 or above) following the enrollment in corequisite courses in mathematics?
    a. To what extent is age a predictor of a student success?
    b. To what extent is sex a predictor of student success?
    c. To what extent is race a predictor of student success?

d. To what extent is socioeconomic status (as measured by receipt of a Pell grant) a predictor of student success?

e. To what extent is the type of math corequisite course (i.e., STEM or non-STEM) taken a predictor of success?

2. What are the differences in pass rates between students enrolled in STEM and non-STEM corequisite mathematics courses at public higher education institutions in West Virginia?
3. What are the differences in semester-to-semester retention rates between students who enrolled in STEM and non-STEM corequisite mathematics courses at public institutions in West Virginia?
4. What are the differences in students who earned a 2.0 or higher GPA between those who enrolled in STEM versus non-STEM corequisite mathematics courses at public institutions in West Virginia?

Sample and Demographics

West Virginia has 12 public four-year and nine public two-year higher education institutions, serving over 97,000 students in academic year 2018-2019 (West Virginia Higher Education Policy Commission, 2020). Of those 21 institutions, two have never offered developmental education courses and thus, have not offered corequisite support. One two-year institution did not report data to the Commission for reasons unknown to the researcher. Thus, 18 public higher education institutions were included in the study (Appendix B).

The dataset included 16,543 students across these institutions across five academic years. Of these students, not all enrolled in only corequisite mathematics. The study focuses only on the students who enrolled in corequisite mathematics courses across five academic years.

The mathematics-specific dataset included demographic information for 12,556 students. Forty records, however, did not include any demographic information and were thus not included in the analysis, leaving a sample of 12,516. Further, students with race listed in the dataset as “other” were re-coded as minority students. Table 3 shows the student characteristics of the 12,516 students who were included in the analysis.

Table 3

Frequencies of Mathematics Corequisite Course Enrollment from 2015-2020

Course type	Sex		Race		Pell-Recipient		Age	
	Female	Male	Minority	Non-Minority	Pell	Non-Pell	< 24 years	≥24 years
Non-STEM	4,981	2,630	1182	6,429	5,012	2,599	6,645	966
STEM	2,494	2,411	980	3,925	2,760	2,145	4,249	656
Total	7,475	5,041	2,162	10,345	7,772	4,744	10,894	1,622

General Content Analysis of Variables of Interest

To gain a full understanding of the dataset, descriptive analyses of percentage point differences in pass rates, retention rates, and semester GPA between and within student groups were conducted.

Table 4

Differences in Pass Rates by Mathematics Corequisite Course Type and Student Group

	Non-STEM Pass Rate	STEM Pass Rate	Differences within Groups
Male	55.23%	59.44%	-4.11%
Female	64.04%	65.48%	1.43%
Difference between Groups	-8.72%	-6.04%	
≥Age 24	60.87%	62.65%	-1.78%
< Age 24	61.05%	62.49%	-1.43%
Difference between Groups	-0.18%	0.17%	
Non-minority	62.17%	63.77%	-1.60%
Minority	54.82%	57.45%	-2.63%
Difference between Groups	7.35%	6.32%	
Non-Pell	67.26%	68.11%	-0.35%
Pell	57.80%	58.15%	-0.35%
Difference between Groups	9.46%	9.96%	

Table 4 demonstrates the differences in pass rates between and within the student groups by mathematics course type.

The data showed that females in the sample had higher pass rates in both non-STEM and STEM corequisite courses and had slightly higher pass rates in STEM courses than non-STEM courses. Males were less likely than females to pass both courses but were much more likely to pass a corequisite STEM course than non-STEM. There were only small percentage point gaps in pass rates between and among age groups or within age groups. Non-minority (White) students had higher pass rates in both types of courses than minority (non-White) students, while both non-minority and minority students were slightly more likely to pass a STEM corequisite course than non-STEM. Finally, showing the largest percentage point gaps, students who received a Pell grant had a much lower pass rate in either type of course, while there were negligible gaps within the groups.

Table 5 shows the differences among retention rates within and between student groups.

Table 5

Differences in Retention Rates by Mathematics Corequisite Course Type and Student Group

	Non-STEM Retention Rate	STEM Retention Rate	Differences within Group
Male	71.75%	75.32%	-3.57%
Female	75.79%	78.63%	-2.84%
Difference between Groups	-4.04%	-3.31%	
≥Age 24	69.25%	76.22%	-6.96%
< Age 24	75.14%	77.12%	-1.98%
Difference between Groups	-5.88%	-0.90%	
Non-minority	74.51%	77.76%	-3.25%
Minority	73.77%	73.98%	-0.21%
Difference between Groups	0.73%	3.78%	
Non-Pell	76.22%	79.11%	-2.89%
Pell	73.44%	75.36%	-1.92%
Difference between Groups	2.78%	3.75%	

The data displayed in Table 5 show that females who took either type of corequisite mathematics had higher retention rates than male students. Male and female students who took a STEM corequisite course were more likely to be retained versus those who took a non-STEM corequisite mathematics course. Students who were 24 and older had a lower retention rate across both course types; however, they were much less likely to be retained if they were enrolled in a non-STEM corequisite course. White students had higher retention rates than non-White students across both course types and were much more likely to be retained if they enrolled in a STEM corequisite course.

Finally, students who received a Pell grant had a lower retention rate versus those who did not receive a Pell grant. Non-Pell and Pell recipients were both more likely to be retained to the next semester if they enrolled in a STEM course, while non-Pell recipients displayed a larger gap between the two types of courses then Pell-recipients.

Table 6 shows the differences among those who earned a GPA of 2.0 or higher in the semester they were enrolled in corequisite mathematics. Females who enrolled in a corequisite mathematics course earned a GPA of 2.0 or higher that semester at a higher rate than males. Both males and females who enrolled in a corequisite mathematics course were more likely to earn a GPA of 2.0 or higher that semester if they were enrolled in a STEM corequisite course. Students under the age of 24 who were enrolled in a corequisite math course were less likely to earn a GPA of 2.0 or higher that semester, but both age groups were likelier to achieve a GPA of 2.0 or higher if they were enrolled in a corequisite STEM course that semester.

White students who enrolled in either type of corequisite math course were much more likely to achieve a GPA of 2.0 or higher, and both White and non-White students were much more likely to achieve a GPA of 2.0 or higher if they were enrolled in a corequisite STEM course that semester. Pell recipients who enrolled in either type of corequisite math course were much less to achieve a GPA of 2.0 or higher, and both Pell recipients and non-recipients were more likely to achieve a GPA of 2.0 or higher if they enrolled in a corequisite STEM course that semester.

Table 6

Differences in GPA by Mathematics Corequisite Course Type and Student Group

	Non-STEM Rate of GPA ≥2.0	STEM Rate of GPA ≥2.0	Differences within Group
Male	60.76%	64.58%	-3.82%
Female	68.12%	72.21%	-4.09%
Difference between Groups	-7.36%	-7.63%	
≥Age 24	67.60%	71.49%	-3.90%
< Age 24	65.28%	67.99%	-2.71%
Difference between Groups	-2.32%	-3.50%	
Non-minority	66.87%	70.24%	-3.37%
Minority	58.54%	61.33%	-2.78%
Difference between Groups	8.32%	8.92%	
Non-Pell	71.41%	72.91%	-1.50%
Pell	62.55%	65.00%	-2.45%
Difference between Groups	8.86%	7.91%	

Overall, the data on pass rates, retention to the next semester, and GPA of 2.0 or higher showed clear percentage point gaps within and among student groups. To determine whether the student characteristics were predictive of success and understand whether these differences between student groups were statistically significant, the researcher conducted more detailed statistical analyses.

Statistical Test Selection

The researcher used two statistical tests to answer the questions in this study. To answer the first question (i.e., whether there are demographic or course attributes that predict student success), a series of binomial logistic regressions were used. The second, third, and fourth research questions (i.e., whether there were differences in pass rates, semester-to-semester retention rates, or GPA between students in STEM and non-STEM corequisite courses) were answered using a Chi-Square test of two proportions.

Variables

The dataset included age, sex, race, Pell recipient status, and math course type as independent variables. The dependent variables were the student success measures of passing the corequisite mathematics course, retention to the next semester at the same institution, and earning a GPA of 2.0 or higher in the semester of the corequisite mathematics course enrollment. All variables were coded as dichotomous, and Tables 7 and 8 show the coding used.

Table 7

Independent Variable Names and Codes

Variable Name	FEM		MIN		PELL		TRAD		STEM	
Student Group	Female	Male	Minority	Non-Minority	Pell	Non-Pell	<Age 24	≥Age 24	STEM	Non-STEM
Code	1	0	1	0	1	0	1	0	1	0

Table 8

Dependent Variable Names and Codes

Variable Name	PASS		RETAIN		GPA	
Student Group	Pass	Fail	Retained	Not Retained	GPA ≥2.0	GPA < 2.0
Code	1	0	1	0	1	0

Binomial Logistic Regression

To answer the first research question, the researcher used a series of binomial logistic regressions. To use this test, seven assumptions have to be met (Laerd, 2017):

1. There is one dichotomous dependent variable.
2. There is one (or more) independent variable(s) that are measured on a nominal scale.

3. There is no relationship between the observations in each category of the dependent variable and the nominal independent variables are mutually exclusive and exhaustive.
4. There are a minimum of 15 cases per independent variable.
5. There is a linear relationship between the independent variables and the logit transformation of the dependent variable. This applies only if the variable(s) is/are continuous.
6. There is no multicollinearity.
7. There are no significant outliers.

As all of these assumptions either were met or did not apply, the researcher proceeded to use IBM SPSS® Statistics Version 28 to run the analyses. Results from the binomial regressions are found in the next section.

Test of Two Proportions

The test of two proportions, also known as the chi-square test for homogeneity (Laerd, 2016), was used to answer research questions two through four. This test required adherence to four assumptions.

1. There was one independent variable and one dependent variable that were both dichotomous.
2. There is no relationship between the cases in the independent variable groups.
3. There is a minimum sample size of an expected frequency of more than five.
4. There is a large enough sample size that the "normal approximation to the binomial distribution is valid" (Laerd, 2016, p.3).

All of these assumptions were met by the variables used for this study. The researcher proceeded to use IBM SPSS® Statistics Version 28 to run the analyses.

Results

Results from the statistical analyses indicated above are organized and presented by research question.

Research Question 1

The first research question examined the predictive value of selected student characteristics on success (i.e., passing a corequisite course, retention to the next semester, and a semester GPA of 2.0 or above) following their enrollment in STEM or non-STEM corequisite courses in mathematics. Three separate tests were run to test the predictive value of sex, age, race, socioeconomic (i.e., Pell) status, and type of course taken on the three success indicators.

Passing a Corequisite Mathematics Course

A binomial logistic regression was performed to ascertain the potential effects of age, sex, race, Pell recipient status, and type of corequisite mathematics course enrollment on the likelihood that students would pass either type of corequisite mathematics course. Of the five predictor variables, four were statistically significant: sex, race, Pell status, and mathematics course type (as shown in Table 9). Females had higher odds of passing a corequisite mathematics course than males; minority students had lower odds of passing a corequisite mathematics course; students who received a Pell grant had lower odds of passing a corequisite mathematics course; and students who were enrolled in a STEM corequisite course were more likely to pass it than those enrolled in a non-STEM corequisite course. The course type variable (i.e., STEM or non-STEM) was significant at $p < .05$, while the sex, race, and Pell status were significant at $p < .001$. level. The results are presented in Table 9.

Table 9

Logistic Regression Predicting Likelihood of Passing a Corequisite Mathematics Course

Variable	B	SE	Wald	*df*	*p*
Sex	.338	.038	77.733	1	<.001
Age	-.066	.056	1.425	1	.233
Race	-.211	.049	18.836	1	<.001
Pell Status	-.435	.039	121.932	1	<.001
Course Type	.081	.039	4.390	1	.036
Constant	.613	.066	86.239	1	<.001

The Hosmer and Lemeshow test was not statistically significant ($p = .312$), indicating that the model is not a poor fit, as shown in Table 10.

Table 10

Hosmer Lemeshow Test: Passing Course

Step	Chi-Square	*df*	Sig
1	8.242	7	.312

Finally, the model was statistically significant, as evidenced by the Omnibus Test of Model Coefficients, $\chi2(5) = 225.08$, $p < .001$, shown in Table 11. The model explained 2.4% (Nagelkerke R^2) of the variance in pass rates, but correctly classified 62.0% of cases. Sensitivity was 95.9%, specificity was 7.6%, positive predictive value was 62.5% and negative predictive value was 46.5%.

Table 11

Omnibus Tests of Model Coefficients: Passing Course

	Chi-Square	*df*	Sig
Model	225.08	5	<.001

Retention to the Next Semester at the Same Institution

A binomial logistic regression was performed to ascertain the potential effects of age, sex, race, Pell status, and type of corequisite mathematics course enrollment on the likelihood that students who were enrolled in a corequisite STEM or non-STEM mathematics course would be retained to the next semester at the same institution. Of the five predictor variables, four were statistically significant: sex, age, Pell status, and mathematics course type (as shown in Table 10). Females had higher odds of being retained to the next semester than male students; students who were under the age of 24 had higher odds of being retained to the next semester than older students; students who received Pell grants were less likely to be retained to the next semester than those who do not receive Pell grants; and students who were enrolled in a STEM corequisite course had higher odds of being retained to the next semester. The age variable was significant at $p < .01$, while the sex, race, and Pell-status variables were significant at $p < .001$. The results are presented in Table 12.

Table 12

Logistic Regression Predicting Likelihood of Retention to the Next Semester

Variable	B	SE	Wald	*df*	*p*
Sex	.203	.043	22.474	1	<.001
Age	.174	.060	8.313	1	.004
Race	-.077	.055	2.003	1	.157
Pell Status	-.171	.044	14.950	1	<.001
Course Type	.161	.044	13.619	1	<.001
Constant	.911	.072	159.695	1	<.001

The Hosmer and Lemeshow test was not statistically significant ($p = .451$), indicating that the model is not a poor fit (Table 13).

Table 13

Hosmer Lemeshow Test: Retention

Step	Chi-Square	*df*	Sig
1	7.822	8	.451

Finally, the model was statistically significant, as evidenced by the Omnibus Test of Model Coefficients shown in Table 14, $\chi2(5) = 61.684$, $p < .001$. The model explained less than 1% (Nagelkerke R^2) of the variance in retention rates, but correctly classified 75.4% of cases. Sensitivity was 100%, specificity was 0%, positive predictive value was 75.4% and negative predictive value was 0%.

Table 14

Omnibus Tests of Model Coefficients: Retention

	Chi-Square	*df*	Sig
Model	61.684	5	<.001

Earning a Grade Point Average of 2.0 or Higher

A binomial logistic regression was performed to ascertain the potential effects of age, sex, race, Pell status, and type of corequisite mathematics course enrollment on the likelihood that students who were enrolled in a corequisite STEM or non-STEM mathematics course would earn a 2.0 or higher GPA. Females had higher odds of earning a GPA of 2.0 or higher than male students in the semester they were enrolled in the corequisite course. Students who were over the age of 24, did not receive Pell grants, and were White had higher odds of earning a GPA of 2.0 or higher. Students who were enrolled in STEM courses also had higher odds of earning a GPA of 2.0 or higher. The age variable was significant at $p < .01$, while the sex, race, and Pell-status variables were significant at $p < .001$. The results are presented in Table 15.

Table 15

Logistic Regression Predicting Likelihood of Earning a 2.0 GPA or Higher

Variable	B	SE	Wald	*df*	*p*
Sex	.346	.040	76.800	1	<.001
Age	-.190	.058	10.641	1	.001
Race	-.297	.050	35.924	1	<.001
Pell Status	-.414	.041	102.845	1	<.001
Course Type	.157	.040	15.312	1	<.001
Constant	.915	.069	176.127	1	<.001

The Hosmer and Lemeshow test was not statistically significant ($p = .740$), indicating that the model is not a poor fit, as shown in Table 16.

Table 16

Hosmer Lemeshow Test: GPA

Step	Chi-Square	*df*	Sig
1	4.336	7	.740

Finally, Table 17 shows the model was statistically significant, as evidenced by the Omnibus Test of Model Coefficients, $\chi2(5) = 241.463$, $p < .001$. The model explained less than 2.7% (Nagelkerke R^2) of the variance in retention rates, but correctly classified 66.7% of cases. Sensitivity was 100%, specificity was 0%, positive predictive value was 66.7% and negative predictive value was 0%. Of the five predictor variables, all were statistically significant (as shown in Table 17).

Table 17

Omnibus Tests of Model Coefficients: GPA

	Chi-Square	*df*	Sig
Model	241.463	5	<.001

The next three research questions focused on analyzing the differences between students enrolled in STEM and non-STEM courses. While the researcher began to explore the answers to these questions in the Content Analysis by calculating percentage and percentage point differences, a statistical analysis of these differences was needed to determine significance.

Research Question 2

Question 2 asked, “What are the differences in pass rates among students enrolled in STEM and non-STEM corequisite mathematics courses at public higher education institutions in West Virginia?” The researcher used a test of two proportions, Pearson Chi-Square, to answer this question.

Students were placed into either a STEM corequisite mathematics course or a non-STEM corequisite mathematics course. Out of the 12,516 students in the sample, 7,611 were placed into non-STEM mathematics courses and 4,905 students were placed into STEM mathematics courses. Overall, 61.6% of students passed the respective corequisite mathematics courses. Considering course type, however, 4,645 students who were enrolled in the non-STEM courses passed (61.0%), while 3,066 students who enrolled in the STEM course passed (62.5%), representing a difference in proportions of .15. There was a small percentage point gap between the two groups, and the difference between students who passed non-STEM versus STEM courses was not statistically significant at p=.097. The results are shown in Table 18.

Table 18

Pearson Chi-Square for STEM versus non-STEM, Course Passing

	Value	*df*	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.753	1	.097

Research Question 3

With research question 3, the researcher explored the differences in semester-to-semester retention rates among students who enrolled in STEM and non-STEM corequisite mathematics courses at public institutions in West Virginia. The analytical tests done for research question 2, a test of two proportions, Pearson Chi-Square, was also used to answer this question.

Out of the 12,516 students in the sample across five academic years, 7,611 were placed into non-STEM courses and 4,905 students were placed into STEM courses. Overall, 75.4% of students who took either type of corequisite mathematics were retained to the next semester. Considering course type, however, 5,662 students who enrolled in the non-STEM courses were retained (74.4%), while 3,777 students who enrolled in the STEM course were retained (77.0%), representing a difference in proportions of .26.

The difference between students who enrolled in a non-STEM corequisite course and were retained versus those who enrolled in a STEM course and were retained is statistically significant at p=<.001. Thus, students who enrolled in a STEM course were more likely to be retained to the next semester at the same institution. The results of the Pearson Chi-Square are shown in Table 19.

Table 19

Pearson Chi-Square for STEM versus non-STEM, Retention to the Next Semester

Test	Value	*df*	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.965	1	<.001

Research Question 4

To understand another student success metric, specifically GPA in the semester in which students were enrolled in a corequisite mathematics course, the researcher asked the following question: "What are the differences in students who earned a 2.0 or higher GPA between those who enrolled in STEM versus non-STEM corequisite mathematics courses at public institutions in West Virginia?" As was done for research questions 2 and 3, a test of two proportions was conducted to answer this question.

Out of the 12,516 students in the sample, across five academic years, 7,611 were placed into non-STEM courses and 4,905 students were placed into STEM courses. Overall, 66.7% of students who took either type of corequisite mathematics earned a GPA of 2.0 or higher. Considering course type, however, 5,077 students who enrolled in the non-STEM courses earned a GPA of 2.0 or higher (65.6%), while 3,358 students who enrolled in the STEM course earned a GPA or 2.0 or higher (68.5%), representing a difference in proportions of .29.

The difference between students who enrolled in a non-STEM corequisite course and earned a GPA of 2.0 or higher versus those who enrolled in a STEM course and earned a GPA of 2.0 or higher is statistically significant at $p = <.001$. Thus, students who enrolled in a STEM course were more likely to earn a GPA of 2.0 or higher than students who enrolled in a non-STEM course. The results of the Pearson Chi-Square are shown in Table 20.

Table 20

Pearson Chi-Square for STEM versus non-STEM, GPA of ≥2.0

Test	Value	*df*	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.175	1	<.001

Ancillary Findings

Further descriptive analysis of data provided by the Commission included other notable findings, not directly related to the research questions, but still relevant to the postsecondary field. A review of the enrollment in non-STEM versus STEM courses by proportion of student characteristics revealed gaps that may merit further examination and will be discussed in Chapter 5. Table 21 outlines these proportions. For instance, of all females in the sample, 67% were enrolled in a non-STEM course versus a STEM course. Conversely, 52% of male students were enrolled in a non-STEM course. This same trend can be seen for Pell grant recipients (i.e., 64% of Pell grant recipients were enrolled in a non-STEM course versus a STEM course and for those who did not receive Pell grants, this percentage was only 55%). Non-minority students in the sample were enrolled in non-STEM courses at a higher rate than minority students (i.e., 62% for non-minority students to 55% of minority students), even though those of minority racial groups are underrepresented in STEM fields.

Table 21

Proportion of Enrollment in non-STEM Mathematics Corequisite Courses by Characteristic

	Sex		Race		Pell-Recipient		Age	
	Female	Male	Minority	Non-Minority	Pell	Non-Pell	< 24 years	≥24 years
Proportion	67%	52%	55%	62%	64%	55%	61%	60%

Other notable findings came from descriptive analysis of the dataset. Students who passed a STEM mathematics corequisite course were retained at a 90.3% rate. Those who failed the STEM course were retained at a rate of 55%, a percentage point gap of 35.3.

The same holds true for students who enrolled in a non-STEM course. Students who passed the non-STEM course were retained at a rate of 90%. Those who failed the non-STEM course were retained at a rate of 51%, a 39-percentage point gap in retention.

Overall, of students who passed either type of mathematics corequisite course, 91% achieved a GPA of a 2.0 or higher. Among students who failed their mathematics corequisite course, only 28% achieved a GPA of 2.0 or higher. In STEM mathematics corequisite courses, 92% of those who passed earned a GPA of 2.0 or higher. Those who failed earned a GPA of 2.0 or higher at a rate of only 30%. Finally, among students who passed a non-STEM mathematics corequisite course, 90% earned a GPA of 2.0 or higher. Those who failed a non-STEM mathematics corequisite earned a GPA of 2.0 or higher at a rate of only 27%.

Due to the large sample size that includes both two-year and four-year institutions over a series of five academic years, these descriptive statistics contribute to understanding the effect of corequisite support on student success. The implications of these findings are discussed in Chapter 5.

Summary

Through the analysis of the data presented in this chapter, the researcher was able to determine student characteristics predictive of success in STEM or non-STEM mathematics corequisite courses, the GPA earned in the semester the course was taken, and retention to the next semester at the same institution. Further, the researcher found statistically significant differences in retention and earning a GPA of 2.0 and higher among students enrolled in STEM and non-STEM corequisite courses. Discussion of these findings, their implications, and recommendations for future study are found in the following chapter.

Chapter 5

Discussion

The focus of this study was mathematics corequisite support courses and the extent to which they may contribute to enrolled students' success in three specific areas: passing the course(s), remaining in school the following semester, and acquiring a GPA of 2.0 or higher. The current research in the field has demonstrated that the traditional approach to developmental education has been proven unsuccessful in its aims to help students pass gateway courses and graduate with a certificate or a degree (Boatman, 2012; Calcagno & Long, 2008; Clotfelter, Ladd, Muschkin, & Vigdor, 2015; Jaggars, Hodara, Cho, & Xu, 2014; Martorell & McFarlin, 2011). In lieu of traditional remediation or developmental courses, corequisite support has been shown to increase the success of students in terms of passing gateway courses, passing subsequent courses in the same subject, and progressing toward graduation (Denley, 2016; Kashyap & Mathew, 2017; Larance, 2019; Logue et al., 2016; Logue, Douglas, & Watanabe-Rose, 2019; Vandal, 2019; Vandal et al., 2016).

Students across the country are enrolled in mathematics corequisite courses at high rates. This is evidenced in West Virginia where in a five-year period (i.e., academic year 2015-16 to academic year 2019-2020), 12,516 students were enrolled in these courses, both in STEM and non-STEM pathways. To increase gateway course completion rates, retention, and overall student success, the study was imperative to our understanding of what differences, if any, exist between STEM and non-STEM corequisite course completion overall, as well as whether there are any demographic attributes associated with success rates among student populations.

While studies have been conducted to show the effects of corequisite support on student success in gateway courses in mathematics (Denley, 2016; Kashyap & Mathew, 2017; Logue et al., 2016; Logue, Douglas, & Watanabe-Rose; 2019), as well as many that have focused on a particular math course or courses at single institutions (Beamer; 2021; Childers & Shi, 2021; Royer & Baker, 2018; Vestal, Brandenburger & Furth, 2015), there had been no multi-institution, multi-year studies that examined the effects of corequisite support in mathematics on student success, and none that examine the differences between STEM versus non-STEM corequisite course success. This study used data from 2015-2020 from 18 public two- and four-year higher education institutions in West Virginia, to examine the effects of corequisite support in STEM and non-STEM mathematics on student success, as defined by passing the course, retention to the next semester, and a GPA of 2.0 or higher. In this study, the researcher answered the following questions:

1. To what extent do demographic or course attributes predict student success (i.e., passing a corequisite course, retention to the next semester, and a semester GPA of 2.0 or above) following the enrollment in corequisite courses in mathematics?
    a. To what extent is age a predictor of a student success?
    b. To what extent is sex a predictor of student success?
    c. To what extent is race a predictor of student success?
    d. To what extent is socioeconomic status (as measured by receipt of a Pell grant) a predictor of student success?
    e. To what extent is the type of math corequisite course (i.e., STEM or non-STEM) taken a predictor of success?
2. What are the differences in pass rates between students enrolled in STEM and non-STEM corequisite mathematics courses at public higher education institutions in West Virginia?

3. What are the differences in semester-to-semester retention rates between students who enrolled in STEM and non-STEM corequisite mathematics courses at public institutions in West Virginia?
4. What are the differences in students who earned a 2.0 or higher GPA between those who enrolled in STEM versus non-STEM corequisite mathematics courses at public institutions in West Virginia?

Summary of Results

The researcher identified several student characteristics predictive of student success in three measures: corequisite mathematics courses, the GPA earned in the semester the course is taken, and retention to the next semester at the same institution. Further, the researcher found statistically significant differences in retention and the acquisition of a GPA of 2.0 and higher among students enrolled in STEM and non-STEM corequisite courses.

Differences in Success by Sex

Descriptive analysis of the data showed that females in the sample had higher pass rates in both non-STEM and STEM corequisite courses and passed STEM courses at a higher rate than non-STEM courses. Females exhibited a higher retention rate to the next semester than male students, regardless of mathematics course type, but had a lower retention rate than other females if they took a non-STEM course. Females who enrolled in either type of corequisite mathematics course earned a GPA of 2.0 or higher in that semester at a higher rate than males.

Both male and female students who enrolled in a STEM corequisite course had a higher retention rate versus those who enrolled in a non-STEM corequisite mathematics course. Similarly, both males and females who enrolled in a corequisite mathematics course earned a

GPA of 2.0 or higher if they were enrolled in a STEM corequisite course that semester. Males experienced a higher pass rate in a STEM corequisite course than a non-STEM course.

As a predictor variable, sex was statistically significant in relationship to passing a corequisite mathematics course, being retained to the next semester, and earning a GPA of 2.0 or higher. Females had statistically higher odds of achieving all three success measures.

Differences in Success by Age

There were only small percentage point gaps in pass rates between and among age groups or within age groups. Students who were 24 and older (i.e., non-traditional) were retained at a lower rate across both mathematics course types; however, they experienced a much lower retention rate if they were enrolled in a non-STEM course. Students under the age of 24 who were enrolled in a corequisite math course were less likely to earn a GPA of 2.0 or higher that semester than older students, but both age groups were likelier to achieve a GPA of 2.0 or higher if they were enrolled in a corequisite STEM course as compared to those were enrolled in a non-STEM course.

As a predictor variable, age was statistically significant in relationship to being retained to the next semester and earning a GPA of 2.0 or higher. Students who were under the age of 24 had higher odds of being retained to the next semester than older students. Students who were over the age of 24 had higher odds of earning a GPA of 2.0 or higher.

Differences in Success by Race

Non-minority students had a higher course pass rate in both types of courses than minority students, while both non-minority and minority students had slightly higher pass rates in STEM corequisite courses than non-STEM. Non-minority students had higher retention rates than minority students across both course types and were much more likely to be retained if they were enrolled in a STEM course. Non-minority students who enrolled in either type of corequisite math course achieved a GPA of 2.0 or higher at a higher rate than non-minority students, and both non-minority and minority students achieved a GPA of 2.0 or higher at a higher rate if they were enrolled in a corequisite STEM course that semester then in a non-STEM course.

As a predictor variable, race was statistically significant in relationship to passing a corequisite mathematics course and earning a GPA of 2.0 or higher. Minority students had significantly lower odds of passing a corequisite mathematics course and earning a 2.0 or higher GPA.

Differences in Success by Pell Status

Pell versus non-Pell recipients had the largest percentage point gaps in course pass rates; students who received a Pell grant had much lower passing rates in both course types. Students who received a Pell grant and were enrolled in a corequisite mathematics course had a much lower retention rate to the next semester versus those who did not receive a Pell grant. Pell recipients who were enrolled in either type of corequisite math course achieved a GPA of 2.0 or higher at a lower rate than non-Pell students, and both Pell recipients and non-recipients experienced a higher rate of achieving a GPA of 2.0 or higher if they enrolled in a corequisite STEM course that semester.

As a predictor variable, Pell status was statistically significant in relationship to passing a corequisite mathematics course, retention to the next semester, and earning a GPA of 2.0 or higher. Students who received a Pell grant had lower odds of passing a corequisite mathematics course, lower odds of being retained to the next semester, and lower odds of earning a GPA of 2.0 or higher than those who did not receive Pell grants.

Math Course Type and Success

As a predictor variable, math course type was statistically significant in relationship to passing a corequisite mathematics course, retention to the next semester, and earning a GPA of 2.0 or higher. Students who were enrolled in a corequisite STEM course had higher odds of passing it, being retained to the next semester, and of earning a GPA of 2.0 or higher. This aligns with the descriptive statistics outlined for each of the demographic groups. Pass rate, retention rate, and rate of earning a GPA of or over 2.0 were higher in corequisite STEM for every demographic group.

The difference between students who passed non-STEM versus STEM courses was not statistically significant, however. Yet, the difference between students who were enrolled in a non-STEM corequisite course and were retained versus those who enrolled in a STEM course and were retained was statistically significant, as was the difference between students who enrolled in a non-STEM corequisite course and earned a GPA of 2.0 or higher versus those who enrolled in a STEM course and earned a GPA of 2.0 or higher. Those in STEM courses were more likely to be retained and more likely to earn a GPA of 2.0 or higher.

Ancillary Findings

There were notable gaps in course-type (i.e., non-STEM and STEM) enrollment between students by demographic group. Sixty-seven percent of all females in the sample enrolled in a non-STEM course versus a STEM course, while 52% of male students were enrolled in a non-STEM course – a gap of 15 percentage points. Further, 64% of Pell grant recipients were enrolled in a non-STEM course versus a STEM course. Although, those who did not receive Pell grants enrolled in non-STEM courses at a rate of 55% – a gap of 9 percentage points. Most interestingly, non-minority students in the sample were enrolled in non-STEM courses at a higher rate than minority students (i.e., 62% for non-minority students to 55% of minority students), even though minority students are underrepresented in STEM fields. According to Funk and Parker (2018), in the United States, Black people make up 11% of the U.S. workforce overall but represent only 9% of the STEM field. Those of Hispanic ethnicity make up 16% of the workforce, but only 7% of the STEM field.

Students who passed a corequisite mathematics course were retained at a rate 39 percentage points higher than those who failed these courses. Further, students who passed their corequisite mathematics course achieved a 2.0 GPA or higher at a rate of 91%, 63 percentage points higher than those who failed their corequisite mathematics course. These large percentage point gaps hold true when isolating STEM and non-STEM pass rates.

Discussion of Findings and Areas of Further Research

Mathematics in higher education has been described as the single biggest obstacle to students' retention and postsecondary completion (J. Logue, 2016). As a practitioner in the field, the researcher has extensive experience in this space and expected to see gaps in the student success measures; however, finding such broad gaps between student groups, particularly by sex, race, and Pell-status, was unanticipated. These statistically significant differences demonstrate that over the period of this study (i.e., 2015-2020) in West Virginia, particular student characteristics were predictive of success in corequisite mathematics courses and beyond. This study should be continued longitudinally to gauge elimination of the gaps over time.

The most important predictor variable to this West Virginia sample was Pell status. As noted in Chapter 1, the median household income in the state was approximately $48,000 per year, nearly $23,000 lower than the national median household income (U.S. Census Bureau, 2022). Nearly 17% of the West Virginia population lives in poverty, which is 5.4 percentage points greater than the national average (U.S. Census Bureau, 2021). As a proxy for low socio-economic status, students who received the Pell Grant were the third largest population in the study, making up 62% of the overall sample. Table 2, as shown in Chapter 4, shows the frequencies of each student group in the sample and the total enrollment by course type of each group. Table 22 provides the numbers in percentage of the population for review.

Table 22

Demographic Representation in Sample

	Sex		Race		Pell-Recipient		Age	
	Female	Male	Minority	Non-Minority	Pell	Non-Pell	< 24 years	≥24 years
Percent of Sample	60%	40%	17%	87%	62%	38%	87%	13%

Notably, as shown in Chapter 4 and in the Ancillary Findings above, 67% of female students and 64% of Pell recipients were enrolled in non-STEM corequisite mathematics courses, while only 52% of males and 55% of non-Pell recipients enrolled in non-STEM courses. This could be due to students' selected majors or programs of study, as evidenced by Douglas and Salzman (2020), who examined sex in relation to mathematics course-taking and found that "gender differentials are a function of major, not gender" (p. 84). This could also be related to the presence of higher mathematics anxiety in females (Calvert, 1981; Sokolowski, Hawes, & Lyons, 2019), leading females to select majors that are less mathematics intensive. Some studies point to a lack of or lesser spatial skills as a reason that females have higher mathematics anxiety than males (Casey & Ganley, 2021; Sokolowski, Hawes, & Lyons, 2019).

For Pell recipients, the research is less clear about mathematics anxiety, thus for Pell recipients, further study is required to determine the pertinent research questions. With female students, however, there are multiple hypotheses around mathematics anxiety and major selection that can be explored. Both of these gaps (i.e., sex and socioeconomic status) need to be examined, as this is an overrepresentation of females and lower-income students in non-STEM courses.

This is particularly relevant considering the national focus on recruiting women to STEM fields. According to U.S. Census Bureau statisticians, Martinez & Christnacht (2021), in 2019, only 27% of the STEM workforce was female. Martinez and Christnacht (2021) also showed that women in STEM fields out-earn their non-STEM counterparts but are still being paid less than men in those fields. It is imperative that West Virginia further examine the gap between males and females taking STEM courses in order to assist with the diversification of the STEM workforce and to increase female earnings, perhaps increasing the economic stability of the state.

The statistically significant differences in retention and GPA of 2.0 or higher between students in STEM and non-STEM courses is cause for further examination, as well. One may hypothesize that higher-achieving students enroll in (or are placed into) STEM courses at a higher rate than in non-STEM courses; however, as the pass rate difference between courses was small and not statistically significant, this is an area for further research. An examination that incorporates the high school GPA and standardized test scores of students enrolling in these two types of mathematics courses as additional independent variables could further our understanding of the impact of course type on student success by controlling for measures of previous academic performance.

Recommendations for the Field

Several recommendations for further research can be derived from the findings of this study. The differentiated audiences for which recommendations were crafted are education philanthropies, national mathematics organizations, the state of West Virginia, institutional leadership and faculty, and students.

Recommendations for Education Philanthropies and National Organizations

Across the field of postsecondary education, gaps in student success metrics are being analyzed. Education philanthropies like the Bill & Melinda Gates Foundation's Postsecondary Success team (2022), the ECMC Foundation (2022), the Kresge Foundation (2022), and the Lumina Foundation (2022), among many others, have shifted their strategic plans and funding strategies to work to eliminate race and economic status as predictors of student success. Further, mathematics organizations are working toward the implementation of mathematics pathways across the discipline and allowing for multiple measures for placement into these courses to ensure more equitable access to mathematics aligned with a student's desired major (Charles A. Dana Center, 2022, Mathematical Association of America, 2020). As a result of this study and to assist in her professional practice, the researcher aimed to understand whether these equity-centered efforts by philanthropies and mathematics groups are helping to eliminate equity gaps in postsecondary success in a mostly rural, largely White, and poverty-affected state like West Virginia. Clearly, as evidenced by this study, they are not.

Education philanthropies such as the ones outlined above most often provide funding to states, systems, and non-profit education organizations with an aim of scaling reforms to as many institutions and students as possible as a way to maximize their dollars. They also often select certain states or institutions in which to concentrate postsecondary reform efforts, as well. It is recommended that these organizations examine state data like those found in this study to fully understand how student demographics predict student success, particularly in critical areas like mathematics, and direct funds to the institutions with the largest gaps in outcomes. Similarly, an increase in direct funding to institutions, as opposed to states and student success organizations, to provide high-touch technical assistance in the reforms they are seeking to implement could help guarantee uptake and ensure evaluation occurs. These shifts would help them maximize dollars in a more intentional way and help institutions secure the funding they need to implement mathematics reforms.

While organizations like the Mathematical Association of America and the Charles A. Dana Center Mathematics Pathways initiative provide guides, reports, research, and technical assistance about mathematics reforms to faculty and institutions, it is fair to question fidelity in the implementation of these practices based on the results of this study. As mathematics faculty must adopt an open-mindedness and willingness to innovate if these equity gaps are to be closed, mathematics organizations could support grassroots effort around mathematics pathways and corequisite support by highlighting and advancing the careers of those faculty who have successfully implemented the strategies in both non-STEM and STEM courses.

Recommendations for West Virginia

West Virginia has made strides in ameliorating the issues caused by developmental education through the state code (WV§133-21), requiring institutions to implement corequisite support in lieu of developmental courses. This study revealed, however, that this was not enough to address the gaps in success metrics across student groups. The West Virginia Higher Education Commission (Commission) and Council of Community and Technical Colleges (Council) can directly address these gaps in two ways: 1) adding a framework to the state code that relies on multiple measures for placement; and 2) defining standardized, statewide mathematics pathways aligned to majors.

The existing policy includes language around placement into mathematics courses that outlines mathematics assessment test scores (i.e., the SAT, ACT, and ACCUPLACER) for placement into gateway courses. As was reported in Chapter 2, however, single assessment scores are not a reliable measure of student success and often over-place students, particularly students of color, into developmental courses (Bailey, Jeong, & Cho, 2010; Scott-Clayton & Rodriguez, 2015). High school GPA is a more predictive measure for placement (Bahr et al., 2019).

Section 4.2 of the state code details a provision for institutional autonomy around placement decisions, including use of high school GPA, stating "Students not meeting the appropriate math pathway placement score are placed into a college-level, credit-bearing course with required academic support. With Chancellor's permission, institutions can use multiple assessments, including factoring in the high school GPA" (WV§133-21, 4.2, p.2). Multiple measures assessments that include high school GPA as a criterion ensure students are placed into appropriate courses (Fulton, 2016; Strong Start to Finish, 2020). It is recommended that the Commission and Council examine high school GPA as a predictor of student success and, if proven effective, amend the code to include a multiple measures assessment for placement. This change will ensure students who do not need corequisite support are placed into gateway courses at a higher rate, saving students money. It will also provide access to STEM courses for students who may not have been able to access these courses before, potentially increasing the number of Pell recipients and female students in those courses.

Further, it is recommended that the state collect information on which institutions currently offer mathematics pathways aligned to majors or programs of study. With this understanding, the Commission and Council can make an informed decision about standardizing the pathways across the state through the code. If the mathematics pathways -- and the majors to which they align -- are detailed therein, transfers among institutions in the state will be more streamlined. Mathematics pathways ensure that students are placed into courses because of their majors, not their demographics. This will also help to increase the number of female, minority, and older students, as well Pell recipients, in STEM courses. As demonstrated by this study, with more students in STEM, more students can be retained and earn a 2.0 or higher GPA.

Recommendations for Institutions

While institution-specific information was provided in the dataset, the statistical model was not a good fit, according to the Hosmer and Lemeshow test, thus the researcher did not include this information in the findings. It is recommended that each institution examine data in a similar way to understand their specific differences and areas for focus. With the information provided in this study and an examination of their own datasets, administrators and faculty in West Virginia can further refine the corequisite models in place to target additional support to the students who need it most. Administrators and faculty can also collaborate to develop and request permission from the Commission to employ a multiple measures assessment for placement policy to increase the numbers of students in gateway mathematics courses.

The study demonstrated that student characteristics are currently predicting student success and that of the students who fail the mathematics corequisite course, 72% have a GPA lower than 2.0. This means they are failing more than just their corequisite math course, so it is recommended that mathematics departments examine their pedagogical foundations, instructional strategies, the course materials used, and pass rates by course.

Faculty should be encouraged to eliminate practices that stifle learning or encourage a deficit mindset related to mathematics (Hulleman, Tibbetts, Francis, Lubin, Totonchi, & Barron, 2020) and add practices that encourage learning, particularly if section-specific pass rates show gaps by student characteristics, as this may be an indication of implicit biases in teaching practices. Supportive classroom practices include culturally relevant pedagogy and connecting course material to purpose and relevance in students' lives (Hulleman et al., 2020; Mathematical Association of America, 2020). Other student supports should also be provided and communicated to students, like academic coaching, tutoring, proactive advising, and peer support to address the other courses that students are failing. It is further recommended that the Commission and Council provide funding for training on these strategies and practices.

Recommendations for Students

The researcher would be remiss not to include recommendations for those who are the focus of this work. With the findings of this study, students can, and should, advocate on their own behalf to ensure they are offered equitable access to the mathematics course that is aligned to their major and provides them the highest probability of passing, being retained, and earning a high GPA. Student Government Associations across the state can use this study to draft position statements and work with faculty senates to encourage change in the form of multiples measures assessment for placement, mathematics pathways, and inclusive, supportive classroom environments.

Conclusion

This study identified statistically significant gaps in success for students who enrolled in STEM and non-STEM corequisite courses at 18 public institutions in West Virginia. It further identified student characteristics significantly predictive of passing a corequisite mathematics course, being retained to the next semester, and earning a GPA of 2.0 or higher, for students enrolled in both non-STEM and STEM mathematics corequisite courses at these institutions. While there is still much to consider about students enrolled in mathematics corequisite support in West Virginia and across the country, this study provides significant utility to the postsecondary field.

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Appendix A

Exemption from Marshall University Office of Research Integrity

MARSHALL UNIVERSITY®
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Office of Research Integrity

October 4, 2022

Vanessa S. Keadle
7811 Ringtail Circle
Zionsville, IN 46077

Dear Vanessa:

This letter is in response to the submitted dissertation abstract entitled *"The Effects of STEM and Non-STEM Mathematics Corequisite Courses on Student Success at Public Institutions in West Virginia."* After assessing the abstract, it has been deemed not to be human subject research and therefore exempt from oversight of the Marshall University Institutional Review Board (IRB). The Code of Federal Regulations (45CFR46) has set forth the criteria utilized in making this determination. Since the study does not involve human subjects as defined in DHHS regulation 45 CFR §46.102(e) it is not considered human subject research. If there are any changes to the abstract you provided then you would need to resubmit that information to the Office of Research Integrity for review and determination.

I appreciate your willingness to submit the abstract for determination. Please feel free to contact the Office of Research Integrity if you have any questions regarding future protocols that may require IRB review.

Sincerely,

Bruce F. Day, ThD, CIP
Director

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Appendix B

Data Disclosure Agreement

West Virginia Higher Education Policy Commission
West Virginia Council for Community and Technical College System
1018 Kanawha Boulevard, East, Suite 700
Charleston, West Virginia 25301

DATA DISCLOSURE AGREEMENT

WHEREAS, the West Virginia Higher Education Policy Commission (Commission) has collected certain data containing confidential personally identifiable information (PII) that Commission is mandated by federal and state law to protect their confidentiality;

WHEREAS, the Commission is willing to make such data available for research and analysis purposes to improve policy and practice in public postsecondary institutions and to conduct research and program evaluation studies germane to postsecondary education, but only if the research meets the qualifications of a FERPA exception as outlined in 20 U.S.C. § 1232g(b) and (h) – (j) and 34 CFR § 99.31. and data are used and protected in accordance with the terms and conditions stated in this Agreement; and

WHEREAS, Bobbi Nicholson, PhD and Vanessa Keadle desire to study The Effects of STEM and Non-STEM Mathematics Corequisite Courses on Student Success at Public Institutions in West Virginia requiring individual student data from the Commission.

Now therefore, it is agreed that:

Bobbi Nicholson, PhD and Vanessa Keadle, hereinafter referred to as the "Researchers" and the Commission that:

I. DATA PROVIDED

The Commission will provide the Researchers with the following data:

The original sample includes records for students who started as a first-time freshman between the 2015-2016 academic year and 2019-2020 academic year at one of the public West Virginia Two-Year or Four-Year institutions. West Virginia University is excluded from the sample. Each record included in the dataset represents an individual student. Only students who enrolled in a corequisite English or a corequisite math course as their first English or math course after enrolling as a first-time freshman were included. Students might have taken a corequisite course in their first semester or a later semester. Students who enrolled in a developmental English or math course OR enrolled in a college-level English or math course that was not considered corequisite were excluded from the sample. Students who enrolled in courses with annual enrollment of fewer than 10 students were not included in the sample because of student privacy concerns. In addtion, the following data elements are included in the dataset.

Gateway math enrollment (Y/N)	Year(s)
Corequisite math enrollment (Y/N)	2015-2019
Passing gateway/corequisite math with a grade of C or better (Y/N)	2015-2019
Gateway English enrollment (Y/N)	2015-2019
Corequisite English completion (Y/N)	2015-2019
Passing gateway/corequisite English with a grade of C or better (Y/N)	2015-2019
Semester GPA for the semester in which the student enrolled in the corequisite math or a corequisite English course	2015-2019
Returning the following semester or completing a credential/degree in the semester, in which the student enrolled in a coreq math or English	2015-2019
Semester GPA for the following semester after student was enrolled in the corequisite math or a corequisite English course (applicable only to students who returned the following semester)	2015-2019
Gender (male/female)	2015-2019
Age (traditional/non-traditional 25+ years of age)	2015-2019
Race/ethnicity (minority/non-minority)	2015-2019
Pell recipient in the freshman year (Y/N)	2015-2019

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Math gateway/corequisite course academic year	2015-2019
Math gateway/corequisite course number	2015-2019
Number of credits of math corequisite, if different from gateway	2015-2019
Number of credits in a math gateway course in the same subject taken in the same semester and which course is not flagged as coreq.	2015-2019
English gateway/corequisite course academic year	2015-2019
English gateway/corequisite course number	2015-2019
Number of credits in an English gateway course in the same subject taken in the same semester and which course is not flagged as coreq.	2015-2019
Institution name (will be used only to match with the survey and will be anonymized in the dissertation to 2-year/4-year)	2015-2019

If additional data elements are needed and are available, an addendum to this agreement will be drafted without the need to modify it.

II. FERPA

The data listed above are being shared under the Studies FERPA exception as outlined in 20 U.S.C. § 1232g(b) and (h) – (j) and 34 CFR § 99.31.

Studies Exception Conditions

1. Disclosure of PII from student education records must be for, or on behalf of, an educational agency or institution, in order to
   a) Develop, validate, or administer predictive tests;
   b) Administer student aid programs; or
   c) Improve instruction.
2. An educational agency or institution may disclose PII from education records, and a "FERPA permitted entity" may redisclose PII only if
   a) The disclosing educational entity enters into a written agreement with the organization;

III. INFORMATION SUBJECT TO THIS AGREEMENT

A. All data loaned to the Researchers by the Commission for the purpose set forth in the approved Research Proposal Application which is attached hereto and made a part of this Agreement as though set forth fully therein (marked as Attachment 1), as well as all information, reports, publications, documents, or data derived from those data.

B. All data containing Personally Identifiable Information (PII) as defined by the federal Family Educational Rights and Privacy Act (FERPA), the Higher Education Act (HEA), Gramm-Leach-Bliley Act (GLB Act or GLBA), Commission policy, or other applicable state and federal law, that are collected or maintained by or on behalf of the Commission and that are loaned to the Researchers and all information derived from those data are subject to this Agreement (referred to herein as the "target data"). The target data under this Agreement may be provided in various forms including but not limited to written or printed documents, CD-ROMs, DVDs, or encrypted electronic file transfers.

C. The Researcher may use the target data only for the purposes stated in the Research Proposal Application and is subject to the limitations imposed under the provisions of this Agreement, which is intended to and does comply with FERPA, the HEA, the GLBA, and all other applicable state and federal laws.

IV. INDIVIDUALS WHO MAY HAVE ACCESS TO TARGET DATA

The Researchers agree to limit and restrict access to the target data to the following three categories of individuals:

A. The Project Leader in charge of the day-to-day operations of the research and who are the research liaisons with the Commission, whose name is set forth in the Research Proposal Application.

B. The Professional/Technical staff in charge of the research under this Agreement, whose names are listed in the Research Proposal Application.

1. The Researchers shall retain the original version of the target data at a single location and shall not make a copy or extract of the target data available to anyone.

2. The Researchers shall maintain the target data, regardless of the medium in an area that has limited access to authorized personnel only. The Researchers shall not permit removal of any target data from the limited access area. Only those individuals who have executed an Acknowledgment of Confidentiality Requirements shall be admitted to the storage area.

3. The Researchers shall ensure that data in storage or transit are protected using a minimum of 128-bit encryption. Access to the target data maintained electronically shall be controlled by password protection. The Researchers shall maintain all printouts, diskettes, or other physical products containing PII derived from target data in locked cabinets, file drawers, or other secure locations when not in use.

4. The Researchers shall ensure that all printouts, tabulations, and reports are edited for any possible disclosure of personally identifiable target data and that cell sizes are ten (10) or more.

5. The Researchers shall establish procedures to ensure that the target data cannot be extracted or accessed by unauthorized individuals.

6. Specific security controls may be appended or added to this agreement as necessary.

B. Destruction of target data.

1. Under Commission supervision, the Researchers shall destroy the target data including all copies, regardless of the medium, within 60 days of the project end date listed in the Research Proposal Application or upon termination of this agreement by either party, whichever occurs first. If an extension has been approved, the destruction date listed in the extension agreement will supersede the project end date established in the Research Proposal Application.

2. The Researchers shall use at a minimum, the purge sanitation method that is consistent with the National Institute of Standards and Technology's Guidelines for Media Sanitation publication when destroying target data. The guidelines are available for review at the following link: http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-88r1.pdf

3. The researchers shall, within 60 days of the conclusion of the research project and successful destruction of all source data, submit to the Commission a notarized Certificate of Destruction which is attached hereto and made a part of this Agreement as though set forth fully therein (marked as Attachment 2).

VIII. TERMINATION OF THIS AGREEMENT

A. This Agreement shall terminate on the project end date stated in the Research Proposal Application, or upon Commission receipt of a notarized Certificate of Destruction, whichever occurs first. The Agreement, however, may be extended by written agreement of the parties.

B. Any violation of the terms and conditions of this Agreement may result in the immediate revocation of this Agreement by the Commission.

1. The Commission may initiate revocation of this Agreement by written notice to the Researchers.

2. Upon receipt of the written notice of revocation, the Researchers shall immediately cease all research activity related to the Agreement until the issue is resolved. The Researchers will have three (3) business days to submit a written Response to the Commission, indicating why this Agreement should not be revoked.

3. The Commission shall decide whether to revoke this Agreement based on all the information available to it. the Commission shall provide written notice of its decision to the Researchers within ten (10) business days after receipt of the Response. These timeframes may be extended for good cause.

4. If revocation is based upon the Researchers' improper handling of PII from the target data or improper proposed publication of target data containing PII that the parties have been unable to resolve, the Researchers agree to return the data, follow all data destruction procedures as outlined in Section VII-B of this Agreement, and not publish or disseminate the proposed article or other document.

5. If the Researchers publish target data in an article or other document without first submitting to the Commission for review and the article or other document contains PII, the Commission reserves the right, in addition to terminating this Agreement, to seek legal redress.

IX. MISCELLANEOUS PROVISIONS

A. Attached to this Agreement and incorporated herein are:
   1. Research Proposal Application
   2. Certificate of Destruction

X. SIGNATURE PAGE

By signing below, the official of the Research Organization certifies that he or she has the authority to bind the Research Organization to the terms of this Agreement and that the Research Organization has the capability to undertake the commitments in this Agreement.

1. Location at which the target data will be maintained and analyzed. 7811 Ringtail Circle, Zionsville, IN 46077 (External hard drive/home office)	
2. Signature of the Researcher or the Official Representative of the Research Organization Barbara L Nicholson	3. Date 11/07/2022
4. Type/Print Name of Official Barbara L Nicholson	5. email bnicholson@marshall.edu
6. Title Coordinator, EdD in Leadership Studies	7. Telephone 3047462094
8. Mailing Address 100 Angus E. Peyton Dr., South Charleston, WV 25303	
9. Signature of the Principal Research Analyst Vanessa S Keadle	10. Date 11/07/2022
11. Type/Print Name of Principal Research Analyst Vanessa S. Keadle	12. email vanessa@studentreadystrategies.com
13. Title Research Analyst, Doctoral Candidate	14. Telephone 412-582-3334
15. Mailing Address 7811 Ringtail Circle, Zionsville, IN 46077	
16. Signature of Higher Education Policy Commission Representative Zornitsa Georgieva	17. Date 11/07/2022
18. Type/Print Name of Higher Education Policy Commission Representative **Zornitsa Georgieva**	19. email **Zornitsa.georgieva@wvhepc.edu**
20. Title **Director of Research and Analysis**	21. Telephone **304.558.1112**
22. Mailing Address **1018 Kanawha Boulevard, East, Suite 700, Charleston, WV 25301**	

Appendix C

List of Institutions

Four-year institutions	Two-year institutions
Bluefield State College	Blue Ridge Community & Technical College
Concord University	BridgeValley Community & Technical College
Fairmont State University	Eastern West Virginia Community & Technical College
Glenville State College	Mountwest Community & Technical College
Marshall University	New River Community & Technical College
Potomac State College	Pierpont Community & Technical College
Shepherd University	Southern West Virginia Community & Technical College
West Liberty University	West Virginia University at Parkersburg
West Virginia State University	
West Virginia University Institute of Technology	

Appendix D

Notes on the Data from the West Virginia Higher Education Policy Commission

- Each record in the data file represents an individual student.
- Only students who enrolled in a corequisite English or a corequisite math course as their first English or math course were included.
- The academic year for the corequisite math/English course represents the academic year in which the student took the course for the first time. It is possible that students took those courses after their freshman year. It is possible for students to take corequisite English and corequisite math in different semesters of the same academic year.
- Course enrollment includes courses taken in the summer, fall, or spring semester of the academic years between 2015-2016 and 2019-2020.
- Students who enrolled in courses with annual enrollment of fewer than 10 students were not included in the data file due to privacy concerns.
- There are some courses that are corequisite courses but were not flagged as gateway courses. Most of those cases are associated with earlier academic records when institutions were transitioning to implementing the corequisite model courses.
- The grade used in to determine the course passing indicator is based on the grades in courses designated as gateway courses. There are some differences across institutions as to which course is designated a gateway course. At some institutions both the coreq portion and the main course are designated as gateway

courses, on others only the coreq portion is designated as a gateway course, and at other institutions, only the main course is designated as gateway course.

- The passing the course indicator represents a student receiving an A, B, C or P (Pass) grade in the gateway course. If the student received a D, F, W or Incomplete they are considered not passing the course. The grade of any course designated as a gateway math/English course.
- There are cases when students enrolled in multiple sections of the same course in the same semester (first half of the semester course and a later starter course). The highest grade achieved across all attempts in the semester has been taken into consideration for the passing the course indicator.
- Semester GPA represents the GPA for the given semester as reported by the institution.
- If a student took the corequisite English or corequisite math during their last semester and graduated that same semester, they are marked as returning the following semester, but they will not have a GPA for the following semester.

Appendix E

Mathematics Course Coding

Year	College	Course Number	Course Name	Pathway
2016-2017	Blue Ridge CTC	MATH100	Math Essentials	STEM
2016-2017	Blue Ridge CTC	MATH100A	Algebra Essentials	STEM
2017-2018	Blue Ridge CTC	MATH100	Math Essentials	STEM
2017-2018	Blue Ridge CTC	MATH 100A	Algebra Essentials	STEM
2018-2019	Blue Ridge CTC	MATH100	Math Essentials	STEM
2018-2019	Blue Ridge CTC	MATH 100A	Algebra Essentials	STEM
2019-2020	Blue Ridge CTC	MATH100	Math Essentials	STEM
2019-2020	Blue Ridge CTC	MATH 100A	Algebra Essentials	STEM
2015-2016	Bluefield State College	MATH 101	General Mathematics ALP	NONSTEM
2016-2017	Bluefield State College	MATH 101L	General Mathematics with Lab	NONSTEM
2017-2018	Bluefield State College	MATH 101L	General Mathematics with Lab	NONSTEM
2018-2019	Bluefield State College	MATH 101L	General Mathematics with Lab	NONSTEM
2019-2020	Bluefield State College	MATH 101L	General Mathematics with Lab	NONSTEM
2016-2017	Bridge Valley CTC	MATH 111	Math for Health Care	NONSTEM
2016-2017	Bridge Valley CTC	MATH 113	Mathematical Reasoning	NONSTEM
2016-2017	Bridge Valley CTC	MATH 115	Applied Technical Math	STEM
2018-2019	Bridge Valley CTC	MATH 111	Math for Health Care	NONSTEM
2018-2019	Bridge Valley CTC	MATH 113	Mathematical Reasoning	NONSTEM
2018-2019	Bridge Valley CTC	MATH 115	Applied Technical Math	STEM
2019-2020	Bridge Valley CTC	MATH 113	Mathematical Reasoning	NONSTEM
2016-2017	Concord University	MATH 103C	College Algebra	STEM
2016-2017	Concord University	MATH 101C	General Mathematics	NONSTEM
2016-2017	Concord University	MATH 101L	General Mathematics Support	NONSTEM
2016-2017	Concord University	MATH 103L	College Algebra support	STEM
2017-2018	Concord University	MATH 103C	College Algebra	STEM
2017-2018	Concord University	MATH 101C	General Mathematics	NONSTEM
2017-2018	Concord University	MATH 101L	General Mathematics Support	NONSTEM
2017-2018	Concord University	MATH 103L	College Algebra Support	STEM
2018-2019	Concord University	MATH 103C	College Algebra	STEM
2018-2019	Concord University	MATH 101C	General Mathematics	NONSTEM

2018-2019	Concord University	MATH 101L	General Mathematics Support	NONSTEM
2018-2019	Concord University	MATH 103L	College Algebra Support	STEM
2019-2020	Concord University	MATH 103C	College Algebra	STEM
2019-2020	Concord University	MATH 101C	Quantitative Reasoning	NONSTEM
2019-2020	Concord University	MATH 101L	Quantitative Reasoning Support	NONSTEM
2019-2020	Concord University	MATH 103L	College Algebra Support	STEM
2019-2020	Concord University	MATH 105C	Elementary Statistics	NONSTEM
2017-2018	Eastern WV CTC	MATH 121S	College Math Support	NONSTEM
2017-2018	Eastern WV CTC	MATH 121	College Math	NONSTEM
2015-2016	Fairmont State University	MATH 1001	Applied Technical Math I Support	STEM
2015-2016	Fairmont State University	MATH 1007	Fundamental Concepts of Math Support	NONSTEM
2015-2016	Fairmont State University	MATH 1012	College Algebra Support	STEM
2015-1016	Fairmont State University	MATH 1101	Applied Technical Math I	STEM
2015-2016	Fairmont State University	MATH 1107	Fundamental Concepts of Math	NONSTEM
2015-2016	Fairmont State University	MATH 1112	College Algebra	STEM
2016-2017	Fairmont State University	MATH 1001	Applied Technical Math Support	STEM
2016-2017	Fairmont State University	MATH 1007	Fundamental Concepts of Math Support	NONSTEM
2016-2017	Fairmont State University	MATH 1012	College Algebra Support	STEM
2016-2017	Fairmont State University	MATH 1101	Applied Technical Math I	STEM
2016-2017	Fairmont State University	MATH 1107	Fundamental Concepts of Math	NONSTEM
2016-2017	Fairmont State University	MATH 1112	College Algebra	STEM
2017-2018	Fairmont State University	MATH 1407	Fundamental Concepts of Mathematics with Support	NONSTEM
2018-2019	Fairmont State University	MATH 1407	Fundamental Concepts of Mathematics with Support	NONSTEM
2019-2020	Fairmont State University	MATH 1407	Fundamental Concepts of Mathematics with Support	NONSTEM
2017-2018	Fairmont State University	MATH 1430	College Algebra with Support	STEM
2018-2019	Fairmont State University	MATH 1430	College Algebra with Support	STEM
2019-2020	Fairmont State University	MATH 1430	College Algebra with Support	STEM
2015-2016	Glenville State University	MATH 106L	Finite Mathematics with supplemental lab	NONSTEM
2016-2017	Glenville State University	MATH 106L	Finite Mathematics with supplemental lab	NONSTEM
2017-2018	Glenville State University	MATH 106L	Finite Mathematics with supplemental lab	NONSTEM
2018-2019	Glenville State University	MATH 106L	Finite Mathematics with supplemental lab	NONSTEM

2015-2016	Glenville State University	MATH 115L	College Algebra with supplemental lab	STEM
2016-2017	Glenville State University	MATH 115L	College Algebra with supplemental lab	STEM
2017-2018	Glenville State University	MATH 115L	College Algebra with supplemental lab	STEM
2019-2020	Glenville State University	MATH 106S	Finite Mathematics with suppport	NONSTEM
2019-2020	Glenville State University	MATH 115	College Algebra	STEM
2019-2020	Glenville State University	MATH 115S	College Algebra with support	STEM
2019-2020	Glenville State University	MATH 106	Finite Mathematics	NONSTEM
2015-2016	Marshall University	MTH 100	Preparation for College Mathematics A	NONSTEM
2015-2016	Marshall University	MTH 102	Preparation for College Mathematics B	STEM
2015-2016	Marshall University	MTH 121B	Concepts and Applications of Mathematics with Algebra Review (	NONSTEM
2016-2017	Marshall University	MTH 100	Preparation for College Mathematics A	NONSTEM
2016-2017	Marshall University	MTH 102	Preparation for College Mathematics B	STEM
2017-2018	Marshall University	MTH 102	Preparation for College Mathematics B	STEM
2018-2019	Marshall University	MTH 102	Preparation for College Mathematics B	STEM
2019-2020	Marshall University	MTH 102	Preparation for College Mathematics B	STEM
2016-2017	Marshall University	MTH 102B	Abridged Preparation for College Mathematics B	STEM
2017-2018	Marshall University	MTH 102B	Abridged Preparation for College Mathematics B	STEM
2018-2019	Marshall University	MTH 102B	Abridged Preparation for College Mathematics B	STEM
2019-2020	Marshall University	MTH 102B	Abridged Preparation for College Mathematics B	STEM
2016-2017	Marshall University	MTH 121B	Concepts and Applications of Mathematics with Algebra Review	NONSTEM
2017-2018	Marshall University	MTH 121B	Concepts and Applications of Mathematics with Algebra Review	NONSTEM
2018-2019	Marshall University	MTH 121B	Concepts and Applications of Mathematics with Algebra Review	NONSTEM
2019-2020	Marshall University	MTH 121B	Concepts and Applications of Mathematics with Algebra Review	NONSTEM
2015-2016	Mountwest CTC	MAT 100	Occupational Mathematics	NONSTEM
2016-2017	Mountwest CTC	MAT 100	Occupational Mathematics	NONSTEM
2017-2018	Mountwest CTC	MAT 100	Occupational Mathematics	NONSTEM
2018-2019	Mountwest CTC	MAT 100	Occupational Mathematics	NONSTEM
2019-2020	Mountwest CTC	MAT 100	Occupational Mathematics	NONSTEM
2015-2016	Mountwest CTC	MAT 133	Math for Applied Health	STEM
2016-2017	Mountwest CTC	MAT 133	Math for Applied Health	STEM
2017-2018	Mountwest CTC	MAT 133	Math for Applied Health	STEM

2015-2016	Mountwest CTC	MAT 135	Mathematics for Machinist Technology	STEM
2016-2017	Mountwest CTC	MAT 135	Mathematics for Machinist Technology	NONSTEM
2017-2018	Mountwest CTC	MAT 135	Mathematics for Machinist Technology	NONSTEM
2018-2019	Mountwest CTC	MAT 135	Mathematics for Machinist Technology	NONSTEM
2019-2020	Mountwest CTC	MAT 135	Mathematics for Machinist Technology	NONSTEM
2015-2016	Mountwest CTC	MAT 144	Applications in Algebra Expanded	STEM
2016-2017	Mountwest CTC	MAT 144	Applications in Algebra Expanded	STEM
2017-2018	Mountwest CTC	MAT 144	Applications in Algebra Expanded	STEM
2018-2019	Mountwest CTC	MAT 144	Applications in Algebra Expanded	STEM
2019-2020	Mountwest CTC	MAT 144	Applications in Algebra Expanded	STEM
2017-2018	New River CTC	MATH 0091	Math Foundation for Liberal Arts (Pathway to MATH 101)	NONSTEM
2018-2019	New River CTC	MATH 0091	Math Foundation for Liberal Arts (Pathway to MATH 101)	NONSTEM
2017-2018	New River CTC	MATH 0092	Math Foundation for Allied Health/Technical Trades STEM Majors (Pathway to MATH 103 or 104)	STEM
2018-2019	New River CTC	MATH 0092	Math Foundation for Allied Health/Technical Trades STEM Majors (Pathway to MATH 103 or 104)	STEM
2019-2020	New River CTC	MATH 0093	Math Foundation for College Algebra (Pathway to MATH 109)	STEM
2017-2018	New River CTC	MATH 101	General Mathematics	NONSTEM
2018-2019	New River CTC	MATH 101	General Mathematics	NONSTEM
2017-2018	Pierpont CTC	MTH 1207	Fundamental Concepts of Mathematics with Support	NONSTEM
2018-2019	Pierpont CTC	MTH 1207	Fundamental Concepts of Mathematics with Support	NONSTEM
2019-2020	Pierpont CTC	MTH 1207	Fundamental Concepts of Mathematics with Support	NONSTEM
2018-2019	Pierpont CTC	MTH 1200	Intermediate Algebra	STEM
2018-2019	Pierpont CTC	MTH 1201	Applied Technical Mathematics I	STEM
2019-2020	Pierpont CTC	MTH 1201	Applied Technical Mathematics I	STEM
2017-2018	Pierpont CTC	MTH 1203	Applied Math for Industry	STEM
2018-2019	Pierpont CTC	MTH 1203	Applied Math for Industry	STEM
2019-2020	Pierpont CTC	MTH 1203	Applied Math for Industry	STEM
2018-2019	Pierpont CTC	MATH 1210	Introduction to Statistics	NONSTEM
2019-2020	Pierpont CTC	MATH 1210	Introduction to Statistics	NONSTEM
2018-2019	Potomac State College of WVU	MATH 121	Introductory Concepts of Mathematics	NONSTEM

2019-2020	Potomac State College of WVU	MATH 121	Introductory Concepts of Mathematics	NONSTEM
2018-2019	Potomac State College of WVU	MATH 122	Algebra with Applications	STEM
2019-2020	Potomac State College of WVU	MATH 122	Algebra with Applications	STEM
2018-2019	Potomac State College of WVU	MATH 126	College Algebra	STEM
2019-2020	Potomac State College of WVU	MATH 126	College Algebra	STEM
2019-2020	Shepherd University	MATH 107A	Quantitative Reasoning with Lab	NONSTEM
2019-2020	Shepherd University	MATH 109A	Statistical Reasoning with Lab	NONSTEM
2017-2018	Southern WV CTC	MATHEMAT 105A	Practical Math for Industrial Occupations	STEM
2015-2016	Southern WV CTC	MATHEMAT 121A	College Math for General Education	NONSTEM
2016-2017	Southern WV CTC	MATHEMAT 121A	College Math for General Education	NONSTEM
2017-2018	Southern WV CTC	MATHEMAT 121A	College Math for General Education	NONSTEM
2015-2016	Southern WV CTC	MATHEMAT 124A	Technical Math, Enhanced	STEM
2016-2017	Southern WV CTC	MATHEMAT 124A	Technical Math, Enhanced	STEM
2017-2018	Southern WV CTC	MATHEMAT 124A	Technical Math, Enhanced	STEM
2019-2020	Southern WV CTC	MATHEMAT 124A	Technical Math, Enhanced	STEM
2018-2019	Southern WV CTC	MT 121	College Mathematics for General Education	NONSTEM
2019-2020	Southern WV CTC	MT 121	College Mathematics for General Education	NONSTEM
2018-2019	Southern WV CTC	MT 130A	College Algebra, Enhanced	STEM
2019-2020	Southern WV CTC	MT 130A	College Algebra, Enhanced	STEM
2015-2016	West Liberty University	MATH 102	The Nature of Mathematics	STEM
2016-2017	West Liberty University	MATH 102	The Nature of Mathematics	STEM
2017-2018	West Liberty University	MATH 102	The Nature of Mathematics	STEM
2019-2020	West Liberty University	MATH 102	The Nature of Mathematics	STEM
2015-2016	West Liberty University	MATH 160	Introduction to Statistics	NONSTEM
2016-2017	West Liberty University	MATH 161	Introduction to Statistics	NONSTEM
2017-2018	West Liberty University	MATH 162	Introduction to Statistics	NONSTEM
2019-2020	West Liberty University	MATH 163	Introduction to Statistics	NONSTEM
2019-2020	West Virginia State University	MATH 103E	Problem Solving and Number Sense	NONSTEM

2019-2020	West Virginia State University	MATH 111E	Mathematics for Liberal Arts	NONSTEM
2019-2020	West Virginia State University	MATH 118E	"College Algebra with Business Applications"	STEM
2019-2020	West Virginia State University	MATH 119E	Algebraic Methods	STEM
2019-2019	West Virginia State University	MATH 103E	Problem Solving and Number Sense	NONSTEM
2018-2019	West Virginia State University	MATH 111E	Mathematics for Liberal Arts	NONSTEM
2018-2019	West Virginia State University	MATH 118E	College Algebra with Business Applications	STEM
2018-2019	West Virginia State University	MATH 119E	Algebraic Methods	STEM
2018-2019	West Virginia University Institute of Technology	MATH 122	Quantitative Skills and Reasoning	NONSTEM
2019-2020	West Virginia University Institute of Technology	MATH 122	Quantitative Skills and Reasoning	NONSTEM
2017-2018	WVU at Parkersburg	MATH 120	Quantitative Literacy	NONSTEM
2018-2019	WVU at Parkersburg	MATH 120	Quantitative Literacy	NONSTEM
2019-2020	WVU at Parkersburg	MATH 120	Quantitative Literacy	NONSTEM
2017-2018	WVU at Parkersburg	MATH 120E	Quantitative Literacy Enhanced	NONSTEM
2018-2019	WVU at Parkersburg	MATH 120E	Quantitative Literacy Enhanced	NONSTEM
2019-2020	WVU at Parkersburg	MATH 120E	Quantitative Literacy Enhanced	NONSTEM
2017-2018	WVU at Parkersburg	MATH 121	Introduction to Mathematics	STEM
2017-2018	WVU at Parkersburg	MATH 125	Technical Mathematics	STEM
2018-2019	WVU at Parkersburg	MATH 125	Technical Mathematics	STEM
2019-2020	WVU at Parkersburg	MATH 125	Technical Mathematics	STEM
2017-2018	WVU at Parkersburg	MATH 125E	Technical Mathematics Enhanced	STEM
2018-2019	WVU at Parkersburg	MATH 125E	Technical Mathematics Enhanced	STEM
2019-2020	WVU at Parkersburg	MATH 125E	Technical Mathematics Enhanced	STEM
2017-2018	WVU at Parkersburg	MATH 126	College Algebra	STEM
2018-2019	WVU at Parkersburg	MATH 126	College Algebra	STEM
2019-2020	WVU at Parkersburg	MATH 126	College Algebra	STEM
2017-2018	WVU at Parkersburg	MATH 126E	College Algebra Enhanced	STEM
2018-2019	WVU at Parkersburg	MATH 126E	College Algebra Enhanced	STEM
2019-2020	WVU at Parkersburg	MATH 126E	College Algebra Enhanced	STEM

Appendix F

Resume

VANESSA S. KEADLE

HIGHER EDUCATION PROFESSIONAL + ORGANIZATION LEADER

CONTACT

412-582-3334

vanessa@studentreadystrategies.com

7811 Ringtail Circle, Zionsville, IN 46077

SKILLS

- Demonstrable commitment to promoting and enhancing success for students of color and students from low-income backgrounds through the integration of innovative, evidence-based strategies
- Expert in current educational policies and political decisions that affect higher education institutions across the country
- Substantial expertise in holistic implementation that includes data-driven strategies
- Expertise in organizational leadership and culture-building

EDUCATION

Doctor of Education, Educational Leadership
Marshall University, anticipated December 2022

Master of Arts, Higher Education Administration
West Virginia University, December 2008

Bachelor of Science, Psychology
Bethany College, May 2007

SELECT PROFESSIONAL LEADERSHIP

- Bill & Melinda Gates Foundation Postsecondary Ecosystem Committees, 2021-current
  - Equity Committee
  - Service Design and Delivery Committee
- Strong Start to Finish
  - Equity Working Group, 2021
- NASPA Region II
  - Conference Planning Committee, 2014-2015
- West Virginia Association of Student Personnel Administrators
  - Executive Board, 2012-2016
- West Virginia Student Leadership Conference
  - Planning Team, 2012-2017
- Alpha Xi Delta, Gamma Beta Chapter,
  - Faculty Advisor, 2013- 2015

PROFESSIONAL EXPERIENCE

Chief Strategy Officer, Student-Ready Strategies 2019-current

- Provides strategic support to the CEO to ensure organizational success
- Manages organizational culture
- Contributes to intentional, mission-aligned business development
- Contributes to proposal development
- Oversees all client projects with particular focus on those involving postsecondary transformation, developmental education reform, placement and other policy review
- Manages relationships with clients and partners
- Manages team members

Senior Strategy Director, Complete College America 2017-2019

- Provided structured implementation support to 46 state higher education agencies, consortia, and systems to enact reforms
- Led and contributed to grant-writing
- Assisted in grant management - included reporting, budget development and tracking, and activity management
- Provided leadership for CCA directors – includes leading weekly director's meetings and serving as the director's voice in the senior leadership meetings
- Managed the design and deployment of tools and resources for state, system and institutional leaders
- Authored or solicited research reports, briefs and blog posts highlighting evidence of effective implementation
- Managed the qualitative and quantitative data collection and data analysis

Coordinator of Research and Evaluation,
West Virginia Higher Education Policy Commission 2015-2017

- Served in a leadership capacity for coordination of all data collection, research efforts, and Federal reporting
- Developed and monitor applicable research MOUs and related policies
- Collaborated with institutions of higher education, the WV Department of Education, WV RESAs, local county boards of education, and an external evaluator
- Collected, analyzed, reported, and utilized data to improve college access and success rates
- Provided research, planning, and administration leadership on college access and success initiatives for the WV Higher Education Policy Commission.

Director of Student Life, Marshall University 2011-2015

- Developed, disseminated, and employed policy changes that affect the entire university community
- Oversaw the Office of Student Activities including supervision of professional, graduate, and student staff
- Collaborated with Vice President for Assessment to evaluate student organization learning
- Created learning outcomes and assessment plan for student advocacy and organization advising efforts
- Planned, promoted, and executed family programming, such as Parent Weekend, Orientation, and recruitment events
- Produced a successful first-year transition for new students by creating, implementing and assessing the University 100 curriculum

VANESSA S. KEADLE

HIGHER EDUCATION PROFESSIONAL + ORGANIZATION LEADER

TEACHING

Curriculum and Assessment Subcommittee, Marshall University, 2011-January 2015

- Appointed as the Curriculum and Subcommittee chair
- Develop extensive, detailed UNI 100 course curriculum
- Recruited peer mentors and staff facilitators for program
- Created and implement training sessions for staff facilitators and peer mentors
- Worked with IRB to maintain ability to do research on UNI 100 course
- Crafted and employed relevant assessment tools, and utilize data analysis to drive program modification

UNI 100, Facilitator, Marshall University, 2011-2014

- Instructed a class of 30-50 students on topics relevant to student success in college
- Directed a peer mentor
- Managed student crisis situations

Ethical Theories, Co-Teacher, Marshall University, Fall 2014

- Responsible for grading writing submissions for doctoral level course
- Led discussion about ethical theory and philosophy
- Part of doctoral program portfolio program

Human Resources Management, Co-Teacher, Marshall University, Spring 2014

- Managed an online classroom for a Masters level course
- Part of doctoral program portfolio program

Greek Leadership Course, Co-Instructor, Marshall University, 2012

- Implemented a strengths-based leadership curriculum for fraternity and sorority members

GRANT SUCCESS

Secured over 6 million dollars in grant funding for various education-based non-profit organizations, starting in 2017.

SELECT PRESENTATIONS

Presentations in bold font were for large national or international audiences

Keadle, V. "Corequisite Support for Advisors." Baton Rouge Community College, August 2022.

Keadle, V. "Celebrating Collaboration & Model Approach. Panel Presentation." Strong Start to Finish Learning Network Convening, May 2022.

Keadle, V. "A Student-Ready Framework to Advance Student Success." West Virginia Student Success Summit, Virtual, July 2021.

Keadle, V. & Vaulter, K. "From Crisis to Catalyst: Accelerating Student-Ready Transformation in Turbulent Times." The 27th Annual National Conference on Students in Transition, Virtual Conference, October 2020.

Keadle, V. "The Corequisite Approach." Nevada System of Higher Education, Statewide Virtual presentation for advisors, December 2020.

Keadle, V. & Ancel, S. "Leveraging Curricular Maps to Facilitate Reform." Strong Start to Finish Learning Network Convening, Miami, FL, March 2020.

Keadle, V. "Change the Structure, Not the Student." West Virginia Student Success Summit, Morgantown, WV, July 2018.

Keadle, V. & Mala, M. "Merging Silos for Momentum in the First Year." NASPA Annual Conference, Philadelphia, PA, March 2018.

Courts, A. & Keadle, V. "Money Skills & College Access - Tools for Financial Literacy Success." West Virginia Student Success Summit, Morgantown, WV, July 2016.

Keadle, V. & Wolfe, B. "Mentoring: It's not just for students." West Virginia Student Success Summit, Morgantown, WV, July 2016.

Gattuso, M., Kennedy, J., & Keadle, V. "A Toolkit for Meaningful College Visits." NCCEP Annual Conference, Washington, D.C., July 2016.

Keadle, V., Hixson, N., Webb-Hughes, G. "Best Practices for Developing a Successful Multi-Partner Evaluation of GEAR UP." NCCEP Annual Conference, Washington, D.C. July 2016.

Kennedy, J. & Keadle, V. "Txt 4 Success - Utilizing Text Messaging to Promote College Access and Retention." NASPA Region II Annual Conference, Washington, D.C., June 2015.

Stadler, C. & Keadle, V. "Combating Apathy and Lackluster Leadership in Professional Organizations." NASPA Region II Annual Conference, Washington, D.C., June 2015.

Barbour, M., Hurley, S., James, M., & Keadle, V. "Merging silos: Developing a co-curricular assessment plan" West Virginia Association of Student Personnel Administrators, Wheeling, West Virginia, October 2014.

James, M., Lorenz, A. & Keadle, V. "Freshmen first class: Curriculum, assessment and new directions" European First Year Experience Conference, Nottingham-Trent University, Nottingham, England, June 2014.