ABSTRACT

BENTLEY, BRIANNA LOUISE. Exploring the Experiences, Mindset, Math Anxiety, and Math Self-Efficacy of Community College Students and Instructors in a Corequisite Mathematics Course. (Under the direction of Dr. Erin Krupa).

This three-article dissertation examined the implementation and impact of corequisite mathematics courses at four North Carolina community colleges located in urban areas. The first article was a multiple case study that examined student and instructor experiences to determine the characteristics of corequisite courses that students and instructors found effective and their suggested changes to the corequisite course model to make it more effective. Overall, students and instructors found the corequisite course model effective and described the benefits of these courses, specifically the opportunity for just-in-time learning. The second article utilized a convergent parallel mixed methods design to explore the impact of corequisite courses. Findings indicated that characteristics of corequisite courses, specifically just-in-time instruction and the time spent in the course, positively influenced students' math self-efficacy and helped decrease their math anxiety. The increase in students' math self-efficacy was significant. The third article was a convergent parallel mixed methods design that examined the impact of corequisite instructors. Corequisite instructor's pedagogical decisions, personalities, classroom environment, and interactions with students were found to help students develop a growth mindset, decrease their math anxiety, and increase their math self-efficacy. An instructor's disposition, their approach to mistakes and questions, and their ability to create a safe and comfortable classroom environment were noted by students as being the largest influences on their mindset, math anxiety, and math self-efficacy. Community colleges and instructors should consider threats to just-in-time learning when designing corequisite courses, as well as, how instructors can positively influence students' experiences when taking a corequisite mathematics course.

Exploring the Experiences, Mindset, Math Anxiety, and Math Self-Efficacy of Community College Students and Instructors in a Corequisite Mathematics Course

by
Brianna Bentley

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APPROVED BY:

Erin Krupa Committee Chair	Robin Anderson
Jessica Hunt	Jenn Ayscue

DEDICATION

To Dr. Karen Keene. I will be forever grateful for your help and feedback during this process, and I will always wish you could have seen the final results.

BIOGRAPHY

Brianna Bentley was born in Charlotte, North Carolina on October 27, 1995. She comes from a family of teachers, and she knew she always wanted to be one as well. She decided to attend Appalachian State University to complete her Bachelor of Science in Secondary Mathematics Education. After graduating with her undergraduate degree in 2017, she stayed at Appalachian State University to complete her Master of Arts in Mathematics in 2018. She then moved home to teach for a year. She taught high school in Charlotte Mecklenburg Schools during the day and taught at Central Piedmont Community College at night. In the fall of 2019, she began her doctorate in mathematics education at North Carolina State University in Raleigh, North Carolina where she worked as a graduate research assistant for four years. Brianna has accepted a Mathematics Instructor position at Alamance Community College and will begin her job there in the fall of 2023.

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CHAPTER 1: Introduction

Statement of Problem

In most colleges and universities, developmental education is pre-college-level coursework that prepares students to succeed in their first college-level mathematics, reading, or writing course, and is also referred to as remedial education or college remediation. Topics covered in developmental mathematics courses include, arithmetic skills, prealgebra, elementary algebra, and intermediate algebra. Developmental mathematics courses are noncredit bearing and do not count toward students' graduation requirements. Students testing at the lowest levels on a placement exam, or another placement measure such as the SAT or ACT, can be required to enroll in, and pass, as many as four developmental mathematics courses before they can move on to a college-level, credit-bearing mathematics course (Chen & Simone, 2016; Royer & Baker, 2018; Wang et al., 2017). This potential four-course traditional sequence of developmental mathematics takes several semesters to complete and adds to a students' financial burden, while not contributing to their graduation credits.

Most college students are required to pass at least one college-level mathematics course, but unfortunately, developmental education programs continue to be unsuccessful in achieving their goal of preparing students to pass college-level mathematics. Approximately 60% of students entering public two-year institutions and 30% of students entering public four-year institutions of higher education take a developmental mathematics course (Chen & Simone, 2016; Jimenez et al., 2016). Chen and Simone (2016) found that about 50% of students complete and pass all required developmental coursework, but these students still needed to pass their college-level mathematics course. Unfortunately, the percentage of students who continue on to complete their college-level mathematics course is even lower than those who complete their

developmental education requirements and has been calculated to be 33% (Bailey et al., 2010), 22% (Jimenez et al., 2016), or even as low as 11% (Ganga et al., 2018). The pass rates in traditional developmental education programs indicate the system is not preparing students to succeed in and pass their college-level mathematics requirement.

Developmental mathematics has become a serious barrier to educational achievement in our higher education system, since most students required to take developmental mathematics either fail the developmental or the college-level course, preventing them from earning their mathematics credit and ultimately from graduating (Bailey et al., 2010; Chen & Simone, 2016; Edley, 2017; Ganga et al., 2018; Jimenez et al., 2016). When we consider the current demographics in developmental mathematics classrooms, there is a disproportionate number of students from low-income families, first-generation college students, female students, and Black, Native American, or Hispanic students (Bonham & Boylan, 2011; Chen & Simone, 2016). In California community colleges, 110,000 out of 170,000 students who are placed into remedial math never complete their math requirements, and it has been estimated that 50-60% of the racial disparity in degree completion in California community colleges is due to the placement of students in developmental mathematics courses (Edley, 2017). Additionally, Black students are 14 percentage points more likely than White students to be caught in a math trap, which occurs when students never take a college math course higher than their highest level of math in high school (Ngo & Velasquez, 2020). Raising the college-level mathematics completion rates of students placed in developmental mathematics could not only increase graduation rates, but could help close racial, ethnic, and economic performance gaps (Edley, 2017; Logue et al., 2019).

Purpose of Study

Recent policy changes have been made in accordance with research about proposed modifications in the way developmental courses are structured, taught, and delivered. As a result of these state policy reforms, two-year and four-year college systems have redesigned their developmental education programs, which has resulted in the overhaul of the traditional multi-course delivery model (e.g., Hennessey et al., 2021; Kosiewicz et al., 2016; Park et al., 2018; Redl, 2020). At community colleges in North Carolina, the corequisite course model has been adopted for all the entry-level mathematics courses. Corequisite courses allow students who do not initially place into the gateway course to take their college-level mathematics credit with an additional support class. This model allows students to earn their developmental course credit at the same time they are earning their college-level mathematics credit.

Research about the corequisite course model has shown that these courses can successfully help students earn their mathematics credit (e.g., Logue et al., 2019) and can increase students' interest in mathematics (e.g., Campbell, 2015). The purpose of this three-article dissertation study is to describe the beliefs and experiences of students taking corequisite courses and instructors teaching corequisite courses and the interactions between these experiences. In addition to describing student and teacher experiences, this study will analyze students' mindset, math anxiety, and math self-efficacy over the course of the semester to determine the influence of corequisite courses and instructors on students' mindset, math anxiety, and math self-efficacy.

Research Questions

The following research questions will guide this study:

1. What are the experiences of students and instructors of the corequisite course model?

   a. What characteristics of the corequisite course and curricula do students and instructors find effective and ineffective?

2. How do the corequisite courses at a community college impact students' mindset, math anxiety, and math self-efficacy?
   a. Are there significant differences between students' initial and post mindset, math anxiety, and math self-efficacy?
   b. Are there differences between the change in students' mindset, math anxiety, and math self-efficacy given their satisfaction with their final grade?
   c. In what ways does the corequisite course influence students' mindset, math anxiety, and math self-efficacy?
3. How do corequisite mathematics instructors impact their students' mindset, math anxiety, and math self-efficacy?
   a. To what extent does the change in students' mindset, math anxiety, and math self-efficacy vary between instructors?
   b. In what ways does the instructor influence students' mindset, math anxiety, and math self-efficacy?

Brief Summary of Each Article

A three-article dissertation will answer the three research questions. The first article will examine student and instructor experiences while taking or teaching a mathematics corequisite, specifically, what elements of corequisite courses students and instructors found effective, ineffective, and what changes they would make to corequisite courses. A multiple case study design will be used to analyze the unique and similar experiences of students and instructors in corequisite mathematics classrooms. A goal of this study is to identify characteristics of

corequisite courses that are determined by college-level decisions and classroom-level decisions, and then discuss how these course, curriculum, and teaching choices impact the student and instructor experience.

The second article will analyze if there are differences in students' initial and post mindset, math anxiety, and math self-efficacy, as well as, if there are differences in students' mindset, math anxiety, and math self-efficacy given their grade satisfaction. Interview data will be examined to assess if and how the corequisite course structure influenced a change in students' mindset, math anxiety, and math self-efficacy. A convergent parallel mixed methods design will be used, in which qualitative and quantitative data is collected and analyzed separately, and then merged to create a wholistic view of the impact of corequisite courses on students.

The third article studies the extent to which students' mindset, math anxiety, and math self-efficacy differed between instructors. In addition, interview data will be examined to assess the influence of corequisite mathematics instructors on students' mindset, math anxiety, and math self-efficacy. The survey and interview data will be analyzed separately, and then merged in this convergent parallel mixed methods study to discuss if and how students' mindset, math anxiety, and math self-efficacy changed over the course of the semester.

Definition of Terms

Key terms are defined for the sake of consistency and understanding amongst readers of this dissertation.

Corequisite (or Support) Mathematics Course: A corequisite developmental mathematics course is taken in the same semester as a gateway mathematics course. The goal of the course is to support students with just-in-time instruction while they are taking a college-level course.

Corequisite mathematics courses are non-credit bearing, but students are required to pass them to earn their mathematics credit that contributes to their graduation requirements.

College-level (or Gateway) Mathematics Course: A credit-bearing mathematics course that contributes to a student's progress towards graduation.

Mathematics Course Pathways: There are five mathematics pathways that students can choose from. Each pathway includes a corequisite and a college-level mathematics course. The course students are required to take is determined by their major and degree. The five course pathways with corequisite and gateway courses are: (1) Math Measurement and Literacy, MAT 010 and MAT 110; (2) Algebra/Trigonometry I, MAT 021 and MAT 121; (3) Quantitative Literacy, MAT 043 and MAT 143; (4) Statistical Methods I, MAT 052 and MAT 152; and (5) Precalculus Algebra, MAT 071 and MAT 171. See Appendix A for a description of each of these courses.

Transition Math, MAT 003: This course is a developmental math course that helps students develop their foundational math content knowledge. Students might be required to take this course before they can take a corequisite and paired gateway course. Not all students are placed in this course, and not all colleges currently have this course. If a college does not offer this course, the students who would have taken Transition Math previously are allowed to take the corequisite and paired gateway course instead.

Mindset: An individual with a fixed mindset believes they have a certain amount of intelligence and that failing at a task indicates incompetence. An individual with a growth mindset believes that they can work to increase their intelligence by making learning a priority and that they can learn from their mistakes.

Math Anxiety: Feelings of fear, discomfort, or apprehension when confronted with mathematics or the thought of doing mathematics that interferes with an individual's mathematics performance.

Math Self-Efficacy: An individual's confidence and belief in their ability to do math.

CHAPTER 2: Exploring the Experiences of Community College Instructors and Students in a Corequisite Mathematics Course

Introduction

Developmental mathematics courses are being restructured and redesigned by colleges and universities (Kosiewicz, 2016; Ganga et al., 2018; Park et al., 2018) in an effort to improve the historically low pass rates of students placed into developmental mathematics (e.g., Bailey et al., 2010; Chen & Simone, 2016; Jimenez et al., 2016). Some of these policy changes include improving the accuracy of student placement into developmental courses, consideration of strategies to minimize student attrition and acceleration of students into college-level courses, providing more structured and coherent paths through developmental requirements that are more relevant to students' programs of study, and pairing developmental education reforms with comprehensive institutional reforms (Ganga et al., 2018).

When policymakers, colleges, departments, and instructors consider how to increase the pass rates for students in developmental mathematics, they must consider reworking the entire system, from classroom-level changes to college-level changes. This study will focus on the changes that came as a result of a state-wide adoption of corequisite courses in developmental education at North Carolina community colleges. The following research questions will guide this study: (a) what are the experiences of students and instructors of the corequisite course model?; and (b) what characteristics of the corequisite course and curricula do students and instructors find effective and ineffective?

In the next section, math traps are defined and their damaging effects on students are discussed. Next, factors that affect student learning while completing their developmental mathematics coursework are examined. Then, the corequisite course model is defined and

implications for change are reviewed at the college and departmental level as well as at the classroom and student level. Finally, student placement in developmental mathematics, specifically corequisite courses is discussed, and then student achievement in corequisite courses is summarized.

Literature Review

The "Math Trap"

High school and community college curriculum misalignment and inaccurate placement have significant effects on students' placement in their mathematics courses (Ngo & Velasquez, 2020). Approximately 25% of community college students are incorrectly placed into their mathematics course (Scott-Clayton et al., 2014), and approximately 20% of all college students begin their mathematics courses at a level lower than they are expected to pass and in a redundant course compared to their high school mathematics courses (Ngo, 2020). These students were labeled by their high schools as college ready, but when they entered college, they experienced immobility and repetition in their math course-taking trajectory.

A math trap occurs when students never take a college math course higher than their highest level of math in high school (Ngo & Velasquez, 2020). For example, if a student took and passed the Math 1, 2, and 3 sequence in high school, they would experience a math trap if they were required to take a pre-algebra or algebra course. This course placement would result in this student being forced to repeat material they were exposed to in high school and would also place them at a starting point lower than their highest high school math credit. For these students, some can continue in their mathematics credits and take a course higher than their high school math courses, but those who never take a course higher than their high school math courses are considered to be trapped.

This phenomenon of trapped students may at first glance seem improbable, but unfortunately, about half of the community college students enrolled in mathematics courses experience a math trap (Ngo & Velasquez, 2020). When Ngo and Velasquez (2020) analyzed which students were trapped, they found that the chances of being trapped varied across colleges; but that Asian and Pacific Islander, Black, and Latinx students have a greater chance of becoming trapped when compared to their White peers when controlling for highest high school math course, 12th grade GPA, college, and initial mathematics placement level. Once students are placed into developmental math, it is important to understand the factors affecting student learning in these courses.

Factors that Affect Student Learning in Developmental Mathematics

Researchers have tried to determine what factors affect student completion of developmental mathematics courses. Generally, the factors can be sorted into non-academic and academic factors (Acee et al., 2017). Non-academic factors include interferences related to economic, familial, and personal considerations. Acee et al. (2017) found students who listed more nonacademic factors affecting completion were less likely to pass their developmental mathematics course, had lower semester GPAs, and were less likely to continue with their coursework the following semester. Moreover, older students and females listed significantly more nonacademic reasons for interfering with their coursework.

In addition to nonacademic factors, there are several academic factors that affect student success in developmental mathematics courses. Academic factors include interferences related to mathematics, strategic learning problems, and college logistics (Acee et al., 2017). Guy, Cornick, and Beckford (2015) developed a model that determined the impact of affective characteristics on student achievement on their final exam and found that motivation in mathematics was

positively correlated and self-confidence in mathematics was negatively correlated with final exam achievement. One possible explanation proposed for these results was that developmental mathematics students who have high confidence levels at the beginning of the semester may not be as engaged with their learning initially, which could eventually catch up to them. When they expanded the outcome to be passing a credit-bearing course with a C- or higher and not just final exam performance, enjoyment of mathematics became a significant predictor of success. It seems intuitive that if a student enjoys a class and subsequently the subject, then they will perform higher in the long term when compared to their peers who do not enjoy the course and/or subject.

The Corequisite Course Model

A recent course redesign that has replaced the traditional developmental mathematics sequence is a corequisite course model. A corequisite developmental mathematics course is taken concurrently (e.g., Logue et al., 2016; Childers et al., 2021) or sequentially (e.g., Min & Eugene, 2019; Redl, 2020) with a gateway mathematics course in a single semester. Thus, students are able to earn both their developmental and college-level mathematics credits at the same time. A concurrent corequisite course can be taken in the form of a lab (e.g., Atkins & Beggs, 2017; Kim, 2016) or a weekly workshop (e.g., Kashyap & Mathew, 2017; Mireles et al., 2014). A sequential corequisite course covers the developmental mathematics material at the beginning of the semester before moving on to cover the gateway mathematics material (Min & Eugene, 2018; Redl, 2018). In sequential corequisite courses, student achievement in the developmental course does not affect student enrollment in the gateway course at some institutions (Redl, 2018), but other institutions require students to pass a final exam at the end of the developmental mathematics material before they can proceed to take the gateway course

(Min & Eugene, 2018). The implementation of corequisite courses in developmental mathematics programs is just one aspect of the structural redesign in colleges, departments, and classrooms that must be undertaken to increase the effectiveness of these courses.

At the College and Department Level

The adoption of the corequisite course model seeks to reduce or eliminate time students spend in developmental mathematics courses, thus reducing or eliminating exit points (e.g., Atkins & McCoy, 2016; Logue et al., 2019). Colleges and universities have implemented holistic placement guidelines that considered multiple measures for student placement (e.g., Hennessey et al., 2021; Kashyap & Mathew, 2017), rather than solely relying on one math placement exam score. Various math pathways, such as College Algebra, Quantitative Reasoning, and Statistics, were offered for students depending on their major (e.g., Finder-Atkins & Stockdale, 2017; Min & Eugene, 2018). In addition, the corequisite course model is most likely new to most students. Thus, it is imperative that there is student buy-in and understanding of this course format from the beginning (Campbell & Cintron, 2018). It is also important for instructors to understand the format of corequisite courses at their university.

Some colleges used the same instructor for both the corequisite and gateway course (e.g., Childers et al., 2021; Kim, 2016; Redl, 2018), but other colleges had two instructors, one from the Developmental Education Department and one from the Mathematics Department (e.g., Atkins & Beggs, 2017, Atkins & McCoy, 2016). In a pilot of corequisite courses in Louisiana, institutions reported that having the same instructor teach both courses would create cohesiveness between the courses and promote student success (Campbell & Cintron, 2018). Similarly, instructors involved in a pilot study at a private college saw an added benefit to teaching both courses because they were familiar with their students' learning needs and could

better assist them to understand the course content (Kashyap & Mathew, 2017). At some colleges and universities, it was impossible to have the same instructor teach both classes because the Developmental Education and Mathematics Departments are in different colleges.

Corequisite and gateway course alignment required appropriate and consistent pacing of both courses (e.g., Atkins & McCoy, 2016, Mireles et al., 2014). Department created pacing guides can help ensure students are learning just-in-time curriculum in the corequisite course that will help them understand the content in their gateway course. In the instances where there are two instructors teaching the corequisite and gateway course, it is important that there is frequent communication between instructors to ensure there is alignment between the content of each course (Atkins & Beggs, 2017; Atkins & McCoy, 2016). Although, one advantage to having two different instructors is the opportunity to provide students with multiple perspectives about the material (Atkins & McCoy, 2016).

At the Classroom and Student Level

Researchers argue that the purpose of the corequisite developmental mathematics course is to build students' knowledge and peer relationships through group work (e.g., Kim, 2016; Logue et al., 2019), discussion (e.g., Finder-Atkins & Stockdale, 2017), reflection (e.g., Logue et al., 2019; Logue et al., 2016), and other learner-centered and cooperative learning strategies (e.g., Atkins & Beggs, 2017, Atkins & McCoy, 2016). Time in the corequisite course is spent reviewing the necessary prerequisite material for the gateway course and can also be spent discussing any content from the gateway course that students were struggling to understand (e.g., Childers et al., 2021; Kashyap & Mathew, 2017). In addition, graphing calculators and online homework tools, such as MyMathLab, have been used by instructors (e.g., Hennessey et al., 2021; Mullins, 2018). Formative assessments are used frequently in the corequisite course to

inform students and instructors of their progress (e.g., Atkins & McCoy, 2016; Campbell, 2015), and if students needed additional assistance, they are frequently referred to tutoring (e.g., Kashyap & Mathew, 2017; Redl, 2018).

Student Placement and the Corequisite Course Model

The students stuck in a math trap experience immobility and repetition in their math course-taking trajectory, which can impact their motivation and confidence in their mathematical ability (e.g., Logue et al. 2019). In response to the high percentage of students incorrectly placed, colleges and universities have begun to implement holistic placement guidelines that use information from a students' high school transcript, ACT or SAT math scores, and placement exam scores to place students (e.g., Campbell & Cintron, 2018; Ganga et al., 2018). Studies have shown that the consideration of these multiple measures can more accurately place students into their mathematics course (Childers et al., 2021). To achieve greater placement accuracy, institutions should begin using a combination of measures to determine a students' college readiness if they are not already.

At those colleges and universities already using multiple measures to place students, they can choose to place all students in either a gateway or corequisite course (Atkins & Beggs, 2017) or have multiple cutoffs that place students in a gateway, corequisite, or multi-semester sequence (Childers et al., 2021; Hennessey et al., 2021). There is evidence against longer, traditional developmental mathematics sequences (Childers et al., 2021; Logue et al., 2019) and the negative effects that placement into these sequences can have on students' motivation and confidence (Kashyap & Mathew, 2017). If a corequisite course model is only implemented for some students, institutions should consider streamlining the developmental mathematics sequence for those not yet allowed to enroll in a corequisite course.

Corequisite course models have not always been adopted for all developmental mathematics students because there is concern that the lowest performing students would be overwhelmed and unsuccessful (Childers et al., 2021). Instead, some institutions have chosen to keep the students at the lowest end of the placement spectrum from enrolling in a corequisite model until they have first passed a "foundations" course (Childers et al., 2021). Unfortunately, there are still too many exit points for these students in this two-semester sequence because approximately 72% did not complete the sequence. Childers et al. (2021) argue that more students should be allowed to take the corequisite course model to decrease the number of students lost in this developmental mathematics "pipeline."

Student Achievement in the Corequisite Course Model

One way to measure student achievement in corequisite mathematics courses is to compare the final course and exam grades of students in the corequisite, gateway, and the traditional developmental mathematics sequence. Kashyap and Matthew (2017) compared the final exam and course grades of students, and their results showed that students taking a corequisite course in conjunction with their gateway mathematics course scored similarly when compared to their peers in the gateway course who did not take the additional corequisite course. In addition, both of these groups of students significantly outperformed students in a traditional developmental mathematics course. Therefore, we can conclude that the corequisite course at this college helped underprepared students pass their college-level mathematics course at higher rates and more efficiently than their peers trapped in a traditional developmental mathematics sequence. In addition, Kim (2016) found a statistically significant difference in students' pre-test scores between students in a corequisite and gateway mathematics course, but there was no significant difference in final exam scores. We would expect there to be differences in pre-test

scores, but the final exam scores allow us to infer those students placed in developmental mathematics were able to improve their mathematical skills and understanding to a level comparable to their peers who were initially placed into gateway mathematics courses.

Another way to measure student achievement in corequisite mathematics courses is to compare how long it takes students to pass a college-level math course. Atkins and Beggs (2017) found that students in a corequisite course had a higher chance of passing than their peers in an emporium model, classes held in large computer labs through an online program, 79% and 75% respectively. The students placed in the corequisite course completed their developmental and college-level math requirement in one semester compared to the students in the emporium model who had to take a multi-semester sequence. Thus, when we compare the students from the study who were deemed underprepared to take a college-level course, students in the corequisite passed their course at a higher rate and did so quicker. In addition, Childers et al. (2021) found that on average, students placed in a gateway mathematics course earned their college mathematics credit in 1.05 semesters, students in a corequisite course model took 1.03 semesters, and those placed in a traditional developmental mathematics sequence took 2.31 semesters. Students face a time and cost burden when they are enrolled in traditional developmental mathematics, but this burden is alleviated when students are placed in a corequisite course model instead. Thus, there is evidence for the success and effectiveness of the corequisite course model compared to the traditional developmental mathematics course sequence.

Research regarding developmental mathematics has explored: (a) the pass rates and exam scores of students in the corequisite course model compared to the traditional course sequence (e.g., Atkins & Beggs, 2017; Childers et al., 2021; Hennessey et al., 2021); (b) lessons learned from instructors implementing corequisite courses (Campbell & Cintron, 2018); (c) the

relationship between student achievement in corequisite mathematics courses and student mathematics self-efficacy (Kim, 2016); and (d) the relationship between various placement measures and student success in a corequisite course (Finder-Atkins & Stockdale, 2017). There is extensive research about developmental mathematics, but this research tends to focus solely on students or instructors, instead of considering both perspectives. Thus, there is limited research about the experience of instructors and students and how their experiences relate.

This study will use qualitative research methods to explore and describe experiences of community college instructors and students to create a holistic image of the corequisite mathematics classroom. The community colleges in this study have adopted a concurrent developmental mathematics corequisite course format, where students take a developmental mathematics corequisite course and a college-level mathematics course simultaneously (e.g., Atkins & Beggs, 2017; Kim, 2016).

Methodology

A multiple-case study design (Yin, 2018) was utilized to explore the experiences of community college students and instructors of corequisite mathematics courses. This research design allows for the preservation of the unique experiences of students and instructors, as well as the exploration of the common perceptions of the corequisite course model. The two cases in this study, students and instructors, took or taught a corequisite mathematics course at a North Carolina community college in the Spring or Fall of 2022. Even though students were enrolled in various courses and instructors were teaching one or more course, the corequisite course format at the colleges creates a similar experience no matter the course pathway. Even though the math content covered in each course pathway is different, the purpose and goals of the corequisite course do not vary. Corequisite courses are designed to provide extra time for students to learn

the necessary developmental material needed to succeed in their gateway course, time and space to ask questions about material from their gateway course, and study skills lessons that help address other factors that could be affecting student success in math classes, such as mindset and math anxiety. In the next sections, I will state the research questions, and then describe the study participants, the data collection process, the data analysis, and my positionality.

Research Questions

The following research questions guided this study:

1. What are the experiences of students and instructors of the corequisite course model?
    a. What characteristics of the corequisite course and curricula do students and instructors find effective and ineffective?

The Community Colleges

Community colleges across North Carolina that offered corequisite mathematics courses were recruited to participate. The dean or department heads of the math departments from nine of the largest community colleges in North Carolina located in urban locations were emailed and asked if they would be willing to participate in the study. Community colleges were purposefully selected based on demographic similarities. They are all located in a major city in North Carolina and are some of the largest community colleges across the state. Four colleges, which I will refer to as community college A, B, C, and D, agreed to participate in this study. See Table 1 for a description of when corequisite courses were implemented at these four community colleges, the Transition Math and corequisite placement cutoffs, and if an instructor teaches both the corequisite and gateway courses or if two instructors teach the corequisite and gateway courses.

All North Carolina community colleges utilize the same course objectives for the five course pathways. These course objectives are provided by the North Carolina Community

Table 1

Overview of Corequisite Courses at the Four Community Colleges

	Community College A	Community College B	Community College C	Community College D
The semester corequisites were implemented	Fall of 2019	Spring of 2019	Fall of 2020	Fall of 2019
Transition Math placement cutoff	H.S. GPA < 2.2	No Transition Math	H.S. GPA < 2.2	H.S. GPA < 2.2
Corequisite placement cutoffs	$2.2 \leq$ H.S. GPA < 2.8	H.S. GPA < 2.5	$2.2 \leq$ H.S. GPA < 2.8	$2.2 \leq$ H.S. GPA < 2.8
Instructor teaches both courses	Yes	No	Yes	Sometimes

Note: High school GPAs are unweighted.

College System (NCCCS) and course descriptions for the five mathematics pathways can be found in their course library (NCCCS, n.d.). Thus, the same five course pathways were being offered at each of the colleges. See Table 2 for an overview of the number of credit and contact hours for each course pathway.

Table 2

Number of Credit and Contact Hours for the Five Mathematics Pathways

Course Pathway	Course Number	Credit Hours	Total Credit Hours	Contact Hours	Total Contact Hours
Math Measurement & Literacy	010	1	4	2	6
	110	3		4	
Algebra/Trigonometry I	021	2	5	3	7
	121	3		4	
Quantitative Literacy	043	2	5	3	7
	143	3		4	
Statistical Methods I	052	2	6	3	8
	152	4		5	
Precalculus Algebra	071	2	6	4	9
	171	4		5	

Participants

Instructors and students were asked if they were willing to complete an interview. All the corequisite instructors at the four colleges were emailed and asked to participate in an interview, resulting in 13 instructors who completed an interview. All students in corequisite courses at the four colleges were invited to complete a survey in the spring and fall semesters of 2022, where the last question asked them if they would be willing to be interviewed. The students who volunteered were contacted via email. Six students volunteered to be interviewed in the spring of 2022, and three completed an interview. In the fall of 2022, 56 students volunteered, and eight students completed an interview. Due to the limited response from potential participants, I did not purposefully select participants; instead, I interviewed all instructors and students who expressed interest in participating. The number of participants who completed an interview is detailed in Table 3. Table 4 details which college each student attended and what course they took. Table 5 details what college each instructor teaches at and what courses they have taught.

Data Collection

Instructors and students were interviewed about their experiences teaching and taking a corequisite course. Interviews were semi-structured to allow for follow-up questions. Interviews were conducted and audio recorded via Zoom, lasted between thirty minutes to an hour, and

Table 3

Number of Instructor and Student Interview Participants

	Community College A	Community College B	Community College C	Community College D		Total
	Fall 2022	Fall 2022	Fall 2022	Spring 2022	Fall 2022	
Instructors	4	5	2	0	2	13
Students	2	2	0	3	4	11
Total	6	7	2	3	6	24

Table 4

Overview of Student Interview Participants

College	Participant Pseudonym(s)	Course Modality	Course Pathway
A	Jasmine, Jose	Asynchronous	Quantitative Literacy
B	Cameron	In-Person	Quantitative Literacy
	Nate	In-Person	Algebra/Trigonometry I
D	Nick	Asynchronous	Precalculus Algebra
	Aaron, Ethan, Jackson, Rebecca	In-Person	Precalculus Algebra
	Kaden	In-Person	Quantitative Literacy
	Shanelle	In-Person	Statistical Methods I

participants were compensated for their time with a $15 Amazon gift card. Interview questions asked students about any concerns they had when they signed up for a corequisite mathematics course, what they thought was effective and ineffective about the corequisite course model, what they would change about corequisite courses, and their corequisite instructors' teaching style. Interview questions asked instructors about their experience teaching developmental mathematics, any concerns they had when they started teaching corequisite courses, what they find effective and ineffective about the corequisite courses structure, and their teaching style/philosophy. Interviews were transcribed by the researcher. See Appendix B for the student interview protocol and Appendix C for the instructor interview protocol.

Data Analysis

Throughout the interviewing and transcription process, the creation of memos was necessary to gather information about the key features of corequisite courses and their effectiveness. These memos served as the foundation for the codebook (see Appendix D). Once all the interviews were completed and transcribed, descriptive coding (Saldaña, 2013) was used to capture the experiences of students and instructors and their opinions about corequisite courses. Initial codes included: comparing the modalities, lectures, corequisite assignments,

Table 5

Overview of Instructor Interview Participants

College	Participant Pseudonym	Course Modalities	Course Pathways
A	Amy	In-person	Quantitative Literacy; Precalculus Algebra
	Bianca	Asynchronous In-Person	Math Measurement & Literacy; Quantitative Literacy; Precalculus Algebra
	Mikayla	Asynchronous In-Person	Math Measurement & Literacy; Algebra/Trigonometry I; Quantitative Literacy; Precalculus Algebra
	Trinity	Asynchronous In-Person	Quantitative Literacy
B	Caroline	Asynchronous In-Person Synchronous	Math Measurement & Literacy; Quantitative Literacy; Statistical Methods I; Precalculus Algebra
	Lizbeth	Asynchronous	Precalculus Algebra
	Paige	Asynchronous In-Person	Math Measurement & Literacy
	Ruby	Asynchronous In-Person	Quantitative Literacy; Statistical Methods I
	Valeria	Asynchronous In-Person Synchronous	Quantitative Literacy
C	Diana	Asynchronous	Quantitative Literacy; Precalculus Algebra
	Kyle	Hybrid	Algebra/Trigonometry I
D	Samantha	Asynchronous In-Person	Quantitative Literacy; Statistical Methods I; Precalculus Algebra
	Sophia	Asynchronous In-Person	Math Measurement & Literacy; Algebra/Trigonometry I; Quantitative Literacy

materials created for class, use of real-world problems or examples, communication with students outside of class, class size, placement, and recommending one instructor versus two instructors. A second researcher also coded a fifth of the interviews, which helped refine the codes and their meanings. Agreement was 93.17%. This process of establishing reliability was helpful to build trustworthiness.

The instructor and student perspectives were initially coded and summarized separately for a within-case analysis (Yin, 2018). Then, codes were combined into four broader themes (Saldaña, 2013), corequisite course characteristics determined at the college and department level, corequisite courses characteristics determined at the classroom level, changes that have been or that could be made to corequisite courses, and their overall recommendation of corequisite courses. Next, I conducted a cross-case analysis that sought to identify the shared experience of students and instructors in corequisite mathematics courses (Yin, 2018). I wrote memos while completing the within-case analysis and used these to help construct the cross-case analysis. Similar and contrasting evidence was explored to create a holistic description of the corequisite classroom at these community colleges by describing the experiences of students and instructors as well as the effective characteristics of a corequisite course. The combination of student and instructor interviews with researcher memos written throughout the data collection and analysis process helped ensure trustworthiness of the results.

Positionality

I am a White, monolingual, cisgender woman in her late twenties from North Carolina. I have experience teaching as a high school mathematics teacher and an adjunct community college mathematics instructor. Although I do not have developmental mathematics teaching experience, my experience teaching Quantitative Literacy at a North Carolina community college and Precalculus at a North Carolina high school made me more familiar with the curriculum in these two course pathways. To address this, I reviewed the course descriptions at each college for each of the five course pathways to help me understand the five corequisite course pathways.

I interviewed participants with diverse backgrounds, which might have influenced the interactions and responses I received from participants. Some of the student interview

participants might have viewed me as an authority figure given my past teaching experience, but this dynamic might not have been true among all students since some were older than me. Instructor interview participants might have viewed me as an outsider who lacked teaching experience, which could have impacted their willingness to open up and share their true feelings during the interview. On the other hand, instructors and students might have been more willing to share both their positive and negative experiences teaching and taking corequisite courses because I was not connected to their college in any way.

Findings

Student and instructor comments were categorized into four larger themes: characteristics of corequisite courses determined by the college or department, characteristics of corequisite courses at the classroom level, changes that have been or that could be made to corequisite courses, and their overall recommendation. Each of these themes will be discussed from the student and instructor perspective. Then a cross-cases analysis explored the shared experience of students and instructors in corequisite mathematics courses.

Characteristics of Corequisite Courses Determined by the College or Department

This theme details the characteristics of corequisite courses that are determined by the NCCCS, the college, and the department that corequisite courses fall under. These characteristics were grouped into the following subthemes: (a) wrapping their head around the transition from the previous developmental model to corequisite courses; (b) structure and politics of developmental and mathematics departments; (c) advantages and disadvantages of corequisite courses; (d) the scheduling and amount of time spent in the course; (e) curricular materials provided by the college for each pathway and the pacing of the courses; and (f) if one or two instructors teach the corequisite and gateway courses.

Student Perspective. Student opinions about the characteristics of corequisite courses determined by the college or department are discussed below.

Advantages and Disadvantages of Corequisite Courses. Overall, three out of 11 students found corequisite courses to be effective uses of their time. Jasmine liked that the course held her accountable for "doing the problems and practicing" and Ethan thought it was "just helpful overall." Even though Nate did not see his corequisite course as being super beneficial for himself because he had a good grasp of the math, he "could definitely see why somebody who isn't up to speed could definitely gain from the corequisite course." Three students were worried when they signed up for their corequisite course that there "was going to be a gap in [their] knowledge" (Nick) because it had been several years since high school math for these students. Another student was worried, but they recognized they just needed to work on their time management.

Cameron, Nate, and Shanelle all appreciated the corequisite course and found it helpful. Shanelle even said she "wouldn't change anything about the way it's [the corequisite] setup." Aaron liked that the corequisite course was not super weighted because he felt that this took "a lot of pressure off of the course" which also made it feel like the corequisite course was "just there to help you." Three students specifically noted the effectiveness of the corequisite class size. Each of these students were in corequisite courses with approximately 10 students and they liked this smaller class size because it allowed for more one-on-one time with their instructor and helped them feel more comfortable speaking up in class.

Nine students made comments related to their learning in the corequisite course. Nate felt that he was able to get up to speed very quickly and Nick thought that he "wouldn't have been able to do anything [in the gateway class] without learning it again in the [corequisite] class."

Cameron enjoyed the course and thought his instructor was very helpful. Ethan thought it was helpful because the corequisite course "made [him] do work outside of class that [he] might not have done otherwise." Aaron, Jackson, Rebecca, and Shanelle all discussed the advantages of the just-in-time structure of corequisite courses. Aaron could "think back to lessons that [he] definitely would not have gotten if it wasn't for the support class" and Jackson recognized that the corequisite course helped him "get ready for the 171 [gateway Precalculus Algebra] work." Kaden and Rebecca both felt that they would not have done as well as they did in their gateway without the support from their corequisite course.

The Scheduling and Amount of Time Spent in Corequisite Courses. Depending on the course students were taking, the time in the corequisite and gateway course could vary anywhere from six to nine hours a week. In addition, students could have their corequisite and gateway course on the same day or on different days of the week. When Kaden initially signed up, he was annoyed by how many hours and days he had to attend class, but by the end of the semester he realized that it was beneficial and helpful in learning the material. Similarly, Aaron was initially mad when he signed up for the corequisite because he had to show up to campus every day for math, but he quickly changed his mind and realized it was a good thing that his corequisite and gateway courses were on different days "because if it were immediately after, [he] would have math fatigue and would not pay attention to whatever was after." Ethan thought the time spent in his corequisite class "was a good amount of time because it filled in the gaps on the days where [he] didn't have the normal [gateway] class." Ethan also liked that he was doing math every day because he was not forgetting things he needed to know from one class to the next. Nate also liked that the corequisite course gave him time to seek help when he needed it. Some students

had the course back-to-back. Cameron liked that the courses were back-to-back, while Jackson felt burned out by the time the corequisite class was over.

The Curriculum and Pace of the Corequisite Courses. Aaron, Cameron, Jackson, and Rebecca all felt that their corequisite and gateway courses were too rushed and that there was too much content to cover in the courses. These students were taking the Quantitative Literacy and Precalculus sequences. On the other hand, Ethan thought that his Precalculus corequisite was a little slow at times and he liked the pace of his gateway course better. It should be noted that Ethan did not feel stressed taking the corequisite course and he claimed to remember most of the content being covered from high school. At Community College D, students were given workbooks that covered everything they were going to learn over the course of the semester, and Jackson found this to be really helpful and thought it was a good study tool. Kaden liked that the corequisite course was not setup like a study hall and that he was learning lessons that aligned with his gateway course. Aaron, Cameron, Jackson, and Rebecca also felt that the content covered in the corequisite and gateway courses was well aligned.

Having One Instructor or Two Instructors Teach the Corequisite and Gateway Courses. Of the students interviewed, six out of 11 had the same instructor and five had two different instructors for their corequisite and gateway course. All the students with two instructors took the course in-person, while only half of those who had one instructor took the course in-person. Nate and Rebecca both took the courses in-person with one instructor. They liked that they had the same teaching style in both courses, they did not have to communicate with two people, and their instructor could see their progress and how to help them. Cameron's corequisite instructor would work through problems like their gateway instructor but would also show them new methods that might be easier for them to understand. Aaron, Ethan, and Shanelle

all thought an advantage of having two instructors was that they were exposed to multiple methods to solve problems, which helped them to understand concepts better and allowed them to pick the best method for themselves. The opportunity to learn multiple solution methods was only noted as being ineffective when the corequisite instructor showed their students a shortcut, which the gateway instructor specifically did not teach because it did not work for all types of problems. Cameron and Kaden both recognized that their instructors were in communication for their courses to be as aligned as they were. Aaron mentioned how he thought the instructors should have "communicate[d] a little bit more because a lot of the class is, 'did she talk about this method?' and 'I don't know the way this professor does this.'" He felt that his instructors should have communicated more about what problems they were covering in class and how they worked through problems to avoid the corequisite instructor having to ask their students the questions mentioned above.

Instructor Perspective. Instructor opinions about the characteristics of corequisite courses determined by the college or department is discussed below.

Wrapping their Head Around the Transition to Corequisite Courses. Corequisite instructors mentioned how they had to wrap their head around the new course format when their colleges transitioned from their previous developmental math course structure. Specifically, Mikayla detailed how "corequisite courses are not meant to be an extra job" and if she's "giving them all this extra work to do in the corequisite," she is "just creating more stress" for the students rather than supporting them. Other instructors were worried about students feeling overwhelmed since they had two math courses and were also worried about making sure the corequisite course was matching up with the gateway course appropriately and in a way that helped students. Bianca liked the transition to corequisite courses because it gave them an

opportunity to build up students' "growth mindset and additional study skills and things that they need" and she liked that corequisite courses were looking at "building more of the rounded student instead of just focusing on the math."

Structure and Politics of Developmental and Mathematics Departments. At Community College B, the developmental courses and math courses were formerly taught by faculty in different departments. These two departments have since merged and two instructors mentioned how this has made communication easier and helped build relationships between the developmental and math faculty. An instructor at one of the other colleges where the developmental and math faculty are still split into two departments believes that there is an "attitude problem" in the math department for two reasons. One, they do not seem interested or invested in what is occurring in the corequisite course. Two, there is the impression that the math department does not feel they can make their instructors teach a gateway with corequisite students more than one semester in a row. For example, at Community College C, Kyle sets up the schedules for corequisite courses and he likes to put his "best cheerleaders and best coaches" in these courses, but he sees how corequisite courses can zap their energy because corequisite students require so much additional support.

Advantages of Corequisite Courses. Seven out of 13 instructors specifically described how they thought corequisite courses positively affect students: (a) they provided just-in-time learning; (b) they helped students through their gateway credit and towards graduation; (c) there was space to build more confident math students; and (d) there was space for students to ask questions. In addition, instructors thought that students placed in corequisite courses had better attitudes compared to students placed in the past developmental courses because the students were able to see how everything they were learning in the corequisite course was helping them

be successful in their gateway course. Instructors at Community Colleges B and D also liked that the corequisite courses had smaller cap sizes than the paired gateway courses, and they thought that this allowed students a chance to form a relationship with their instructor that they might not have in a larger class and allowed instructors a chance to spend more time working with students one-on-one.

The Scheduling and Amount of Time Spent in Corequisite Courses. Corequisite courses increase the amount of time a student is spending in math class a week, and instructors mentioned advantages of having this extra time. Amy especially liked that she could "go through the material slower and get that extra practice in." Other instructors were worried that the amount of time students are spending in class "can be an additional challenge to students who already struggle with math" (Ruby) and can be "a lot of math at one time" (Diana). This is especially true for students taking the Precalculus pathway because it has nine contact hours.

The Curriculum and Pace of the Corequisite Courses. At Community College A, B, and C, instructors are given suggested pacing guides by their departments, and it is common to share BlackBoard course shells, especially with a new instructor for that course. Kyle described how at Community College C, the BlackBoard shell for corequisite courses has "a lot of videos and examples of fractions and decimals and factoring" that covers the content from the previous developmental math courses that existed before corequisite courses. Instructors can pull lessons from these resources or direct students who need extra help to specific lessons that they might not have time to cover in their corequisite course. At Community College D, all corequisite students are given a workbook. Sophia described these as being "awesome" and claims "they are very, very easy to use."

Instructors have found the course pacing in the Qualitative Literacy, Statistical Methods I, and Precalculus pathways to be very fast and described how "in order to stay with the gateway teachers, we have to fly" (Ruby). Instructors have found this to be especially true in the Precalculus pathway where instructors are left wondering, "how can we teach factoring if they don't know how to factor 27?" (Kyle). A precalculus corequisite instructor, worries that since they "have so much to cover and so little time" that she is not sure that they "cover all the prerequisite skills effectively." This instructor thinks that their college has taken advantage of the fact that the NCCCS has broad objectives, and they suggest that the Precalculus objectives at this college be reevaluated to determine if they are truly needed.

Having One Instructor or Two Instructors Teach the Corequisite and Gateway Courses. Bianca, Diana, and Samantha all noted a similar advantage of being the corequisite and gateway instructor; they were able to see where students needed help in the gateway course and then cover this content in the next corequisite course. Because they taught both courses, they were easily able to implement just-in-time instruction, while also allowing them a chance to get to know their students better. Amy and Mikayla both taught at Community College A where they not only taught both the corequisite and the gateway course, but they had the same students in both classes. This allowed them to flow as needed between developmental and gateway content, instead of only covering developmental content on certain days and times. They were able to cover and devote time to what their students needed, when they needed it. At the other colleges, the corequisite courses included a subset of students from the paired gateway. Three instructors at Community College B discussed two benefits of having two different instructors. One, a student was exposed to two teaching styles. Two, students appeared to be more open with their

corequisite instructors and would come to them for help when they were having an issue in their gateway course or with their gateway instructor.

Instructors indicated that when there are two instructors teaching the corequisite and gateway course, communication between them was extremely critical. Instructors mentioned how gateway instructors share their pacing guides with corequisite instructors, and how they should also let them know anytime there are changes. In addition, corequisite instructors mentioned they will reach out to their paired gateway instructor about specific concerns regarding students or other administrative items. Some colleges ask that paired instructors touch base once a week, but this is not monitored by the department. Overall, corequisite instructors have found that some gateway instructors are good about communicating, while others are not.

Characteristics of Corequisite Courses at the Classroom Level

This theme considers the characteristics of corequisite courses that are decided by students and instructors. At the participant level, students and instructors can make decisions that impact their experience taking or teaching corequisite mathematics courses. Instructors determine how their classroom looks and what the everyday experiences for the student will be. In addition, students had to decide what course modality to take when they signed up for a corequisite course, and this decision affects their experience.

Student Perspective. The classroom level experiences in corequisite courses will be grouped by the three students who took an asynchronous corequisite course and the eight students who took their corequisite course in-person. In addition, the course modalities are compared, and a summary of their instructor's teaching style is provided.

Enrollment in Asynchronous Corequisite Course. Three students took their corequisite and gateway course asynchronously: Jasmine, Jose, and Nick. Jose signed up for an

asynchronous corequisite because he works night shifts and is an army veteran who sometimes gets called in for extended periods of time. In these instances, he does not have access to his computer, so he asked his instructor for extensions in his corequisite and gateway course. Even though the college claims to be veteran friendly, his instructor took points off for his assignments being late. Jasmine's professor recorded lectures of herself teaching the material, which Jasmine thought made a huge difference for her and helped her feel connected in the online environment. In addition, there were guided notes provided to students and real-world examples were frequently used, both of which helped Jasmine "really [understand] everything as she was teaching it." Nick's instructor incorporated study skills lessons and assigned homework through Cengage, an online homework software.

Various assignments were incorporated into the corequisite courses by asynchronous instructors, including, practice problems, discussion boards, Desmos lessons, and a 'check for understanding.' Nick stopped doing the Desmos lessons because there were also Desmos lessons in his gateway course that covered the same content. In Nick's class the discussion board required students to post about something they were struggling with, and he felt that this became a "checking the box kind of a thing" since he found answers to his questions immediately. Jose's course had different dates on the course site than on the syllabus, causing him to become "super confused" about when assignments were due. Nick and Jasmine both felt that the communication with their instructor via email was effective and that their instructors provided detailed explanations that were positive and supportive. Contrastingly, when Jose would reach out to ask for help, his instructor would send YouTube videos back in response and he would sometimes have to "wait a few days to get an answer." For students in asynchronous courses, it is crucial

that there is effective communication between them and their instructor and that their questions are answered in a timely manner. Otherwise, students will be left feeling unsupported.

Nick felt that since he was doing everything on his own and no one was watching him, that he did not devote as much time to his course as he should have. He knew if he had spent a little more time on the course, then he "easily [could have] gotten a very solid A." On the other side of that, Jasmine felt that she "really did get a lot out of it" because she put the time and effort needed into the corequisite course. Jose had a negative experience taking an asynchronous corequisite course. He did not "understand the point of the support class," felt like he "couldn't even understand what was going on until a month in," and "felt like [he] was drinking out of a fire hose." In addition, Jose really missed having "the interaction with the teacher." Overall, Jose "did not see anything positive in the corequisite course" he took asynchronously.

Enrollment in In-Person Corequisite Course. Based on student comments, the in-person corequisite courses split the time in their courses equally between lectures and practice problems. Kaden thought his instructor included a little bit more lecture, while Cameron's instructor focused more on practice problems. Most students discussed the benefits of having their instructors walking around while they were working on problems and how this helped them feel comfortable asking questions. Several students discussed the opportunities given to work with their peers. Nate felt that his instructor encouraged the class to talk with each other. Ethan liked being able to work with his peers and found himself frequently working with the person who sat behind him. Cameron, Aaron, and Kaden all preferred to work alone, as did their peers, so their corequisite classrooms did not have group work, even though they felt that their instructor would have allowed it. In Jackson and Rebecca's corequisite courses, individual work was mainly used, and they did not acknowledge if there were opportunities for them to discuss with their peers.

Cameron liked that his instructor incorporated "everyday scenarios" to help explain concepts, and he felt that this helped him understand the content easier. Rebecca's instructor used small formative assessments and Rebecca liked that she had a chance to see what mistakes she was making prior to taking a test. Kaden's instructor frequently reminded students that they could "send [them] a message in teams" or that they could "send a picture of [their] answers" when they needed to get help outside of class. Study skills lessons were included in the curriculum at Community College D and all the students taking in-person courses remembered watching videos and reflecting on the various study skills topics. Rebecca found the study tips to be helpful and remembered that her instructor encouraged them to "be nice to [themselves]…ask questions…get good sleep…eat something before. [Their instructor] was very positive. And a lot of the studying tips [she] learned [were] definitely things [she] needed to learn." Jackson and Ethan were both familiar with the content covered in the study skills lessons, while Aaron had never had an instructor talk about mental health related topics before.

Why Students Picked their Corequisite Course Modality. When students signed up for their corequisite course they had an important decision to make, what course modality should they sign up for. Cameron and Kaden both recognized that taking an in-person corequisite course was important to them compared to taking it online synchronously or asynchronously. Shanelle was excited about being and learning in person because during COVID she realized how stressful online courses were for her and how she had trouble focusing in online course environments. Two of the students who took the corequisite course asynchronously did so because they did not have another option. One student lived two hours from the college and the other student worked nights.

Their Corequisite Instructor's Teaching Style. Five of the students discussed how they thought their corequisite instructor was nice, how it was obvious their instructor cared about their learning, and how they created positive learning environments. Nate also described how his instructor would not move on until everyone understood the concept, and he even said how their instructor "is probably the best teacher I've had." Rebecca liked that her instructor "just cut to the chase" and how her corequisite instructor's teaching style was "straightforward, relevant, and concise," which made it easy for her to learn. Eight of the students described their instructor's approach to questions and mistakes in the corequisite classroom, and comments made about each of their instructors was reflective of a growth mindset-oriented teaching approach. For example, Rebecca's instructor "encouraged getting all those little mistakes out before the test." Jasmine and Ethan both discussed how they felt safe and comfortable asking questions in the corequisite course. Jose was the only student who felt that their instructor's teaching style was not effective, specifically that his instructor taught at a level that he felt was above the community college level and how he also felt that the student and instructor interaction was lacking.

Instructor Perspective. Depending on the course modality that instructors taught, their decisions about how to structure their corequisite course could vary. The unique pedagogical decisions for asynchronous and in-person corequisite courses are discussed, as well as the things instructors did in both course modalities. Then, the student learning in the various course modalities and a summary of common features of their teaching style is discussed.

Teaching Asynchronous Corequisite Course. Asynchronous courses were primarily structured to have students watch videos, take notes, and then complete assignments based on the notes. Some of these videos were instructor made, some were from the publisher, while other came from YouTube. Assignments in the asynchronous corequisite varied. A popular assignment

was a short quiz that tested students' understanding, referred to as "Quick Checks" or "Check for Understanding." One instructor liked to use a weekly discussion board where students were required to either post a question or answer someone else's question, as well as Desmos lessons. One common feature of asynchronous corequisite assignments was the option for students to take multiple attempts. Paige opens her asynchronous course so students have the option to work ahead, which can help them juggle other classes and real-world responsibilities. Mikayla makes sure that the due dates the same type of assignments are on the same days and times each week to help students easily keep up with when assignments are due.

In addition, asynchronous courses require extra thought by instructors on how to engage and interact with students. Caroline and Lizbeth like to record videos to share with students at the beginning of the semester to share insight into who they are and how the course is laid out. Asynchronous instructors offered online office hours via Zoom and made sure students knew they were always open to meeting with them. Sophia would reach out to students who she noticed were struggling to complete an assignment. Trinity liked to call her asynchronous students because things can be missed in emails, and she wanted "to get a really good understanding of why [they're] frustrated and what's happening." Several instructors mentioned how they asked students to send them screenshots of their work if they had a question and they would mark up the photo with the correct solution and send it back to them. If Valeria had a student ask a question, she would ask them if it was okay if she posted her response for the whole class and she would say, "someone was struggling with this, so I wanted to make it available to everybody." Mikayla really tries to make sure that students know that they are not an island and that she cares about them and their success. She also recently added a weekly check-in assignment for students with four questions: (1) "How are you doing today?" with emoji answer

choices; (2) “Are you watching the lecture videos? Are you taking notes?”; (3) “These are the assignments that are due in MAT 143, have you completed them?”; and (4) “Is there something you need Ms. Mikayla to know? If you don’t you can leave this blank or leave me a funny joke.” She has “created more communication with that itty, bitty little assignment than [she has] gotten with email” and she encourages other corequisite instructors to adopt a similar check-in.

Teaching In-Person Corequisite Course. Instructors who taught in-person corequisites used a combination of lecture and time for practice. Some instructors relied more on lecture, while others relied more on practice. Amy places students into groups, has them work on problems together, and share their group’s answers on the board. She has found that her corequisite students “generally like writing on the board” and “because they’ve done that problem with their group and they don’t have to explain it, they feel comfortable writing it on the board.” Other instructors did not require students to work in groups but allowed students to talk with their peers while working through problems if they wanted to. Caroline’s rationale for this was because she “used to hate required group work because it’s always like one person does it.” Ruby finds that there is not enough time to have students work in groups because there is too much material she has to cover in the corequisite courses. After allowing students time to work on problems, some instructors liked to have students call out all the answers they got on the problem, and if there was more than one answer given, then they would work that problem out on the board with the help of the class.

Teaching Practices Used Among All Course Modalities. Regardless of course modality, instructors liked to use real-world problems to help students relate and connect more to the math they are learning. In addition, five of the 13 instructors who taught the various course modalities provided guided notes to their students. Study skills lessons that focus on growth mindset, time

management, accountability, responsibility, and math anxiety were incorporated by five of the corequisite instructors. These lessons typically included students watching a video, independently reflecting, and then in some in-person classrooms they shared and discussed their reflections as a class. Discussion boards were also used in place of journals for asynchronous students. Sophia makes sure that she covers the growth mindset lesson the first week of class because she wants her students "to have a good, positive mindset going into all their classes" at the start of the semester. After the first week, she thinks of the study skills lessons as being in a "toy chest" and she will cover the most applicable lessons based off the needs of her students. Mikayla and Bianca both talked about how they liked to focus on building confident math students in the corequisites, with Mikayla going so far as to include all the math prerequisite knowledge students need in the gateway course rather than the corequisite. This format allowed for her corequisite course to be primarily focused on providing students support.

Perceptions of Student Success and Learning in the Various Course Modalities. Seven of the 13 instructors mentioned how they think students do better when taking in-person or online synchronous corequisite courses compared to asynchronous. One instructor worried that the students who place into corequisite courses are the ones that need the personal interaction with their instructor, and another instructor worried that these students do not necessarily have the skill sets needed to take an asynchronous course. Attending a corequisite in a face-to-face format allows students to seek immediate answers to their questions and to work with and learn from their peers. Instructors also found that students struggled to understand the corequisite format while taking an asynchronous course. In addition, instructors discussed difficulties with getting asynchronous students to communicate with them. An instructor at Community College B thinks it is especially important to offer more face-to-face formats given their eight-week long

semesters. Contrastingly, one instructor thought her online students were more independent, better at keeping pace with the content, and worked ahead compared to their peers taking a face-to-face format,

Even though instructors recommended in-person courses, they understood the logistical reasons for why students would sign up for an asynchronous course. Caroline sees benefits to various modalities and thinks that students just need to know themselves and if they are "a self-sufficient person and [if they are] the type of person who's going to reach out when [they] need help" or if they are "the type of person who really needs kind of a coach, someone to keep [them] on track." This instructor thinks that "the majority of students do better in-person," but they recognize that students know themselves and the course modality that would benefit them best.

Corequisite Instructor's Teaching Style. Overall, nine of the 13 instructors discussed teaching philosophies that were rooted in growth mindset-oriented beliefs and teaching practices. For example, one of Trinity's mottos for teaching is, "you can learn if you want to learn" and Sophia constantly reminds students that "it's the journey, not the destination." Kyle and Valeria both liked to remind students that they are not perfect, and thus do not expect perfection from their students. Five instructors mentioned their use of positive reinforcement in the classroom, with three teachers specifically describing how they act as "cheerleaders" for their students. Five instructors mentioned creating welcoming classrooms where students felt comfortable and felt that their instructor was there to support them and to help them succeed. Four instructors mentioned their efforts to build relationships with their students in order to build trust and to make them feel more comfortable in their classroom. Teachers built relationships by being personable, high energy, and by finding out about their students' lives. Three instructors discussed how they work to be flexible so that they can meet the diverse needs of their students.

Trinity specifically described this, “I gotta adjust to the student, not the student adjust to me.” Mikayla mentioned how they “love a choir” and always encourage their students to speak up in class, while another instructor always made sure to explain problems in detail to help students feel more comfortable with the content.

Changes to be Made to the Corequisite Course Format

This theme describes suggestions made by students and instructors about how the colleges in this study could change their corequisite course model. Not only did instructors mention changes they wish would be made to corequisite courses, but several instructors detailed positive or negative changes that have been made since the initial implementation of corequisite courses at their college.

Student Perspective. Jackson had his corequisite and gateway course back-to-back, and he wished that he could have taken the courses on different days “because four hours of math was not good” for him and caused him to feel burned out by the time the second course started. Nick wondered if there could have been better placement requirements for the corequisite and suggested an optional placement test if they were placed into the corequisite due to their high school grades, especially because he did not think his grades from high school were the best reflection of who he was as a student now. Nate wished there was an option halfway through the semester for him to stop attending the corequisite course if he were maintaining an A average in the corequisite and a B average in the gateway course. Cameron attended Community College B where they had eight-week courses and he felt that the corequisite and gateway courses were rushed. Jose wished that he could have taken “one class where [he does] both lessons” because going back and forth between two asynchronous courses and two syllabuses made it difficult to figure out what order to complete assignments.

Instructor Perspective. At Community College A and C, the same instructor taught the corequisite and gateway courses. Two of the six instructors from these colleges recommended using one Blackboard shell for the corequisite and gateway courses so that students do not "have to go to two separate place to do homework" (Amy), which would hopefully make the two courses "a little bit more seamless" (Diana). At Community College B, they had one instructor teach the corequisite and another teach the gateway course. One of the five instructors from this college wished corequisite instructors were automatically placed as observers in the gateway Blackboard site to provide opportunities to make sure the content being taught in the corequisite course was aligned to the gateway instructor. Corequisite instructors at Community College D are put in the Blackboard for the gateway course, and they found this to be a helpful reference for making sure the courses are aligned. Caroline taught at Community College B, and she wished they had a basic Blackboard shell for each of the corequisite courses that could be shared with all of the instructors.

When students enter college, they can either place into the gateway course without a corequisite, the gateway course with a corequisite, or Transition Math depending on the college. Mikayla thinks the corequisite placement test at Community College A needs to be improved, while Samantha recommended looking at the math courses students took in high school and their high school math GPA instead of their overall high school GPA. Caroline wishes they could find a better way to place students based on their math ability because she has some students in her corequisite who did not do their best in high school but always loved math. Thus, high school GPA is not the best gauge for these students' math ability and misplaces them into the corequisite when they do not need it. Another instructor also worries that not enough is done to support students who place near the corequisite GPA cutoff for Transition Math. These are the

students who are just barely placed into a corequisite courses based off their high school GPA and are assumed to have the lowest math ability of all corequisite students.

Mikayla also recommended placing all students into corequisites with an option for certain students to opt out because she has had some students place out of the corequisite who wanted to take the course. This would help take away the stigma of remedial math and makes math more inclusive for the diverse populations they are serving. Transition Math is no longer offered at Community College B, and two of the five instructors recommended adding it back as a course because they feel like some students really need that support and cannot jump straight into most of the course pathways. When these students are placed directly into corequisite courses they are not given the opportunity to seek as much one-on-one attention with the instructor to help close the gap in their math knowledge as they would in Transition Math.

Caroline recommended that if corequisite courses were back-to-back, then they should be taught in the same room. From her experience, this limits the number of students who skip the second course and also allows time for the two instructors to touch base about what they are teaching and any student-specific concerns. Samantha felt that the students do better when the corequisite is on different days from the gateway course because students in the back-to-back format are “brain dead” by the time they get to the second course. Some other recommendations from instructors include: (a) changing the course from pass/fail to having a letter grade so that students work a harder and take the corequisite seriously; (b) having the college provide calculators; (c) always pairing the same instructors when two instructors teach the corequisite and gateway courses; and (d) having advisors recommend students take less courses when they take their math credit.

Corequisite courses were implemented as early as the Spring of 2019 at these four colleges, and since this initial implementation, several changes have been made to the corequisite course format by the colleges. At Community College A, instructors still have two Blackboard shells, but are asked to incorporate all of the math content into one My Math Lab course under the gateway course. Then in the corequisite course there are optional support assignments that students can do if they need, as well as lessons and assignments about study skills, growth mindset, etc. At Community College B, the placement cutoff for corequisite courses was lowered from 2.8 to 2.5 and Transition Math was removed. At Community College D, the Qualitative Literacy Corequisite curriculum was updated to be better aligned with the gateway course and this college is currently pushing for more people to teach paired corequisite and gateway courses.

When corequisites were first adopted at Community College B, one corequisite instructor could be matched with up to seven gateway instructors. This format "was like a zoo." Each gateway instructor was teaching a different way and at a different pace, which made it "very hard to pick a centralized topic" to cover in the corequisite and ensured the corequisite could not function as the just-in-time support it was initially designed and intended to be. One corequisite and one gateway instructor are now matched, which is a much better format for ensuring student learning and instructor sanity. In addition, this college has also recently adopted eight-week courses. Three of the five instructors felt these courses were too short to effectively cover the content and did not sufficiently support students, especially for those students with the largest gaps in their math knowledge who were previously being placed into Transition Math. One instructor liked the eight-week courses because students had less courses to keep up with at one time and she felt that her students seemed to be excelling in this course format.

At Community College C, instructors wished they could change the corequisite format, but have not yet received permission. Instead of a concurrent corequisite model, they want to adopt a sequential corequisite model where students take the corequisite for four weeks and then take the gateway for the remaining 12 weeks in the semester. Instructors at this college hoped the NCCCS held off on making any state level changes and wished that they could be allowed to make changes at their college based off what they think their students need. Similarly, an instructor at Community College B thinks the NCCCS needs "to stick with something long enough to see if it actually works" and an instructor at Community College A thinks that the NCCCS likes to "jump ship too soon" and she is exhausted from trying to keep up with all of the recent changes in developmental math. This instructor also thinks that college administrators and the NCCCS office need "to listen and be willing to allow master teachers to experiment to kind of see what works" and that there needs to be more communication with instructors in order to make developmental math across the state better. It should also be noted that a majority of the corequisite course implementation across North Carolina was during COVID.

Overall Recommendation

The final theme was related to a question in the student and instructor interview protocol that asked students if they would recommend corequisite courses to a friend and asked instructors if they would recommend corequisite courses to another college. This theme explores the responses to this interview question to understand students and instructors' overall view of corequisite mathematics courses and if they think they are effective.

Student Perspective. Ethan, Jackson, Jasmine, and Rebecca recommended that their peers take corequisite courses because they: (a) are like an accountability partner (Jasmine); (b) provide extra time to study (Ethan); and (c) are what made the student successful in their

gateway course (Rebecca). Ethan even signed up for a corequisite for his next math course even though it was not required because of how helpful he found it to be. Aaron, Cameron, Jose, Kaden, and Nate recommended taking corequisite courses if: (a) they have taken time off from school (Cameron); (b) they struggle with time management (Cameron); (c) they struggle to understand math (Aaron and Kaden); (d) they are dreading taking a math class (Kaden); (e) there was an option for students to opt out halfway into the course if they were doing well enough in their gateway course (Nate); or (f) they took the corequisite course in-person rather than asynchronously (Jose). Kaden also mentioned how students should not feel discouraged if they are required to take a corequisite because he found it to be a really helpful course. Nick was the only student who did not recommend corequisite courses. He felt that his gateway instructor, the internet, or a tutor were more helpful for him than the corequisite course and would recommend these resources to a peer instead. He also did not think failing the corequisite should impact them if they passed the gateway course.

Instructor Perspective. Caroline recommended having a different instructor for the corequisite and gateway because then students got to experience two teaching styles. Samantha used to agree with Caroline, but due to how difficult communication between instructors has been, she now prefers to teach the corequisite and paired gateway. Amy, Bianca, Diana, Lizbeth, and Sophia all prefer and recommend that there is only one instructor teaching the paired corequisite and gateway courses. Seven of the 13 instructors recommended in-person or online synchronous course formats because they have seen students do better when taking a course in person. Some instructors also think that the students who place into corequisites do not have the skill sets to succeed in asynchronous courses and need the interaction with their instructor that they do not get in an asynchronous environment. Nine of the 13 instructors think that corequisite

courses are working how they are intended. Lizbeth thinks it is a good course model because it is not as discouraging as the previous developmental model and Valeria think it "helps them get through their classes faster." One instructor at Community College B thinks the corequisite course model can work, but that Transition Math needs to be added back. An instructor at Community College C thinks it works for the majority of the pathways, but should be reimagined for the Precalculus pathway, while another instructor at this college thinks the sequential corequisite model needs to be adopted.

Cross-Case Analysis

In this section the student and instructor perspective for each of the four themes will be discussed. In addition, unique experiences and opinions of students and instructors will be highlighted.

Characteristics of Corequisite Courses Determined by the College or Department

Students and instructors both thought the following were effective characteristics of corequisite courses: (a) extra opportunities to work on problems and seek help; (b) smaller class sizes gave opportunities for one-on-one attention from instructors and allowed students and instructors to build a relationship; (c) just-in-time learning provided in the corequisite course; (d) workbooks at Community College D; and (e) when there was one instructor, the instructor saw students' progress throughout the course and could address issues as they arose more easily. Instructors also felt that corequisite courses helped students complete their gateway credit faster than previous developmental math course models, that students had a better attitude and reaction when placed in corequisite courses compared to previous developmental math course models, and that corequisite courses gave students space and time to build their confidence in their math ability.

Depending on the course pathway students took, they were in their corequisite and gateway course for a total of six to nine hours a week. Students were initially upset about having to be in class for this many hours, but they quickly saw why it was necessary. In terms of when courses should be scheduled, several students mentioned that they liked that they had to be in either their corequisite or gateway course every day because it did not give them time to forget and because taking the courses back-to-back would have been too much. For one student who did take the courses back-to-back, they recommended taking courses when they were not on the same day because they were burned out by the time the second course even started. Another student liked that his courses were back-to-back. Thus, there is no right schedule for students, and both formats should be offered. Students should be trusted to know if they would experience math fatigue if they took back-to-back courses, and advisors should help students when making this decision to make sure they are picking the correct format for themselves.

Instructors and students thought that several of the corequisite courses felt rushed and had too much content. Students felt that the Quantitative Literacy and Precalculus Algebra pathways could be slowed down, while instructors felt that the Quantitative Literacy, Statistical Methods I, and Precalculus Algebra pathways could be slowed down. Instructors worried that students became overwhelmed when taking these courses because there was so much content to cover and often did not leave enough time for students to have their questions answered. Some students felt that their corequisite and gateway courses were well aligned, while some students and instructors felt that the communication between the corequisite and gateway teacher was lacking, which impacted the course alignment. Specifically, students recommended that instructors communicate about what problems were covered in each class and how they were taught.

Paired corequisite and gateway courses could either have one or two instructors. When there was only one instructor, students liked that there was only one teaching style and that they only had to communicate with one person. At Community College A, where all of the same students were in the corequisite and gateway course taught by one instructor, instructors liked that it allowed for flexibility in their teaching because they could teach what they needed when they needed, and they did not only have to teach developmental content on certain days at certain times. When there were two instructors, students liked that there were multiple solution methods presented to them. Instructors thought students benefited from seeing two teaching styles and they also felt that students came to their corequisite teacher anytime they had an issue in the gateway course. They hypothesized that this was because the corequisite course was not weighted and they saw their corequisite instructor as only being there to help them.

When two instructors taught the corequisite and gateway course, effective communication between these two instructors was necessary. Instructors suggested that they should touch base weekly and that the course pacing should be shared at the beginning of the course and anytime it was altered. In addition, instructors felt that the corequisite course model was not as effective as possible when instructors were in two different departments (i.e., developmental education and math department), and felt that there was sometimes an "attitude problem" in the math faculty when they were separate. Another concern instructors had was that teaching corequisites can zap an individual's energy and can make them less likely to volunteer to teach corequisite courses in future semesters.

Corequisite Courses at the Classroom Level

The course modality impacted the teaching strategies used in corequisite courses. During in-person courses, students and instructors discussed how a combination of lecture and time for

practice were used, as well as the various opportunities for group and individual work. Students did not feel pressured to work in groups if they did not want to, they liked that they had the option to seek help from their instructor or peers when needed, and they felt comfortable asking for help. Instructors and students discussed the benefits of real-world examples and study skills lessons. Instructors also thought that the guided notes they created helped students keep up with the lectures, while students liked their instructor's use of short formative assessments during class in addition to their availability to help students outside of class.

In asynchronous corequisite courses, students and instructors felt that incorporating real-world examples into the lectures helped students understand the content better and that guided notes were useful. Instructors posted videos, allowed multiple attempts on assignments, incorporated discussion boards and Desmos lessons, and tried to keep due dates consistent. Communication between instructors and asynchronous students was crucial. One instructor found her weekly check in assignment was the most effective way she had found to have her asynchronous students communicate. Instructors also recommended recording a video for the first week of class that explains the course setup, always being open to meet via Zoom, reaching out to students if they noticed students have attempted an assignment multiple times, calling their students, posting answers to questions for the whole class, and asking students for screenshots or pictures of their work when they are struggling so that they can mark up the photo and easily point out where the mistake is occurring. Students noted that detailed explanations from instructors when they asked questions and supportive attitudes when responding are two ways instructors can have good communication with their asynchronous students.

Instructors believe that students struggle to understand the asynchronous layout and were negatively affected by not having face-to-face interactions with an instructor. This was true of

Jose's experience taking an asynchronous course. He did not understand the point of the support class. He also struggled because the dates posted online and on the course syllabus did not match. Whenever he emailed his instructor asking a question, he received a YouTube video in response rather than a detailed explanation that specifically addressed his question. In addition, Jose is in the army and is required to be in the field for extended periods of time, which is one of the reasons he signed up for an asynchronous course. Unfortunately, his instructor did not provide him with any flexibility in terms of due dates and he found himself losing credit on assignments for situations outside of his control. Nick also did not have the best experience taking an asynchronous course because this course modality allowed him opportunities to slack off and he felt that some of the assignments, particularly the discussion board for homework questions, were a waste of his time and unnecessary for him.

The majority of students and instructors discussed a growth-mindset approach to teaching where questions were encouraged and mistakes were celebrated as a part of the learning process in corequisite classrooms. This learning environment made students feel comfortable asking questions, which was a goal of instructors who had a growth mindset-oriented teaching philosophy. Students found that their corequisite instructors were nice, cared about their learning, and were positive. Nate went so far as to say that their corequisite instructor was the "best teacher [he's] ever had." Instructors created a welcoming classroom by, building relationships with their students, being flexible to their students' needs, and acting as cheerleaders for their students by using positive reinforcement.

Changes to be Made to the Corequisite Course Format

It should be noted that all the changes students and instructors wished would be made to corequisite courses related to characteristics of corequisites determined by the college or

department. In terms of course scheduling, in-person corequisite and gateway classes can be scheduled back-to-back on the same day or can be scheduled on different days. One student and one instructor both think that having the courses back-to-back can be too much math and should be on alternate days instead. One instructor said that if they have to be scheduled back-to-back, then they should be in the same room because it helps decrease the number of students who skip.

The placement of students into corequisite courses was discussed by both students and instructors. One student recommended using a placement test instead of relying on high school GPA because the student he was in high school is not the same student he is now, while another mentioned the possibility of opting out of the corequisite halfway through the semester. Both of these students appeared to have been misplaced into the corequisite course as their high school GPA was not the most accurate description of their mathematical ability. Four instructors mentioned that they think corequisite placement needs to be improved and worried that high school GPA is not an accurate measure of students' mathematical ability. One instructor wondered if it was possible to only look at students' high school math courses for their GPA calculation. Another instructor worried about the inclusivity of corequisite courses since those who place above a certain high school GPA are not allowed to take them, and she suggested that everyone be allowed to take corequisite courses.

The layout of the courses in BlackBoard was also something discussed by students and instructors. A student who was taking an asynchronous corequisite and gateway course wished there was just one BlackBoard for the two courses because it was confusing to switch back and forth between the two and it was especially confusing to know what lecture to watch or assignment to do when. Two instructors had the same suggestion as this student. This setup would require the same instructor to teach the asynchronous corequisite and the gateway course.

At Community College A where the same instructor teaches the corequisite and the gateway course, instructors mentioned how they would have all of the math assignments, including those geared towards prerequisite knowledge, in the gateway course and would have study skills assignments, weekly check-ins, and additional practice problems in the corequisite. They found that this ensured students were not getting confused and were completing assignments in the correct order. Being able to clearly understand what order assignments should be completed in is necessary for students to receive just-in-time instruction and is especially important in asynchronous settings where students are required to be more independent.

In order for corequisite courses to work as intended, just-in-time instruction must be delivered to students. This requires the corequisite and gateway course be well aligned. Thus, when there are two different instructors teaching these courses, it is important that instructors communicate what is being taught, when it is being taught, and how it is being taught. In order to make this communication easier, corequisite instructors recommended that they be placed as observers in the gateway instructor's Blackboard course so they can see what students are working on each week. A threat to just-in-time instruction and well aligned corequisite and gateway courses occurred when Community College B used to pair one corequisite instructor with multiple gateway instructors. The gateway instructors were all teaching different content in different ways, which made it impossible for the corequisite instructors to effectively deliver just-in-time instruction. This course setup ensures that students are not receiving the learning they need and ultimately sets students up for failure.

Colleges are still trying to figure out what works best for their students and instructors and are making changes to their corequisite course formats. At Community College D, they are attempting to move toward one instructor teaching the corequisite and gateway courses. At

Community College C, they are looking at moving to a sequential corequisite course format and how they can best alter the Precalculus Algebra sequence to better serve students. At Community College B, Transition Math has been removed as a course offering and eight-week semesters have recently been adopted. One student and three instructors who were interviewed thought that these eight-week courses were too fast and that students are being set up to fail because they are never going to be able to keep up with the content in these courses. Instructors at Community College B recommended that Transition Math be added back. One thing that instructors from all of the colleges mentioned was that they need time to make these changes, especially because they are still transitioning back to "normal" post COVID. The instructors in this study hope to have the time and space to alter the corequisite course model at their colleges before the courses are deemed a success or failure by the NCCCS.

Overall Recommendation

In total, from this sample of 11 students and 13 teachers, seven students and nine instructors would recommend corequisite courses and they think they are working as designed to help students learn material just-in-time. One additional instructor thinks that corequisites work when there is one instructor, and another instructor thinks that the Precalculus Algebra course needs to be redesigned but that the other course pathways are effective. Another student only recommended corequisite courses if students could opt out of taking the corequisite halfway through the course if they no longer needed it. One student and seven instructors recommended in-person or synchronous course modalities instead of asynchronous courses. In terms of whether one instructor should teach the corequisite and gateway course, six instructors in this study recommended one instructor, while only one instructor recommended two instructors. Only one student did not recommend corequisite courses because he felt that he could find the extra help

he needed by asking his gateway instructor, going to tutoring, or searching the internet. Based on comments made by this student, he appears to have been misplaced into corequisite courses and probably would have been fine without taking a corequisite. Finally, two instructors did not think corequisite courses were working as efficiently and effectively at their college as possible, and they suggested sequential corequisites be adopted in addition to alternative solutions being explored for the Precalculus Algebra course. They thought there was too much content to be covered in Precalculus Algebra and it is not suited for the current corequisite course model.

Discussion

The majority of participants (seven of eleven students and nine of thirteen instructors) in this study found corequisite courses effective, especially for students coming back to school or who are not as confident in their math ability. Specifically, some of these participants who found corequisite courses effective felt that corequisite courses gave students space and time to understand the concepts they were learning in their gateway course, to seek help when they were struggling, and to build their confidence in their math ability. The day-to-day activities in corequisite courses involved a combination of lecture, time for practice, group work, and study skills lessons. These findings about how students and instructors found corequisite courses to be effective and beneficial to student success align with research about the positive outcomes related to student achievement in corequisite mathematics classrooms (e.g., Atkins & Beggs, 2017; Kashyap & Matthew, 2017; Kim, 2016). In addition, instructors felt that compared to previous multi-semester developmental course sequences, students completed their gateway credit faster, had a better attitude, and higher motivation. These observations from instructors align with the existing evidence about the negative effects of students placing into traditional

developmental mathematics sequences and the impact on their motivation and confidence (Kashyap & Matthew, 2017).

One concern students and instructors voiced during their interviews was that there was too much content that the colleges expected the corequisite and gateway courses to cover. This was primarily true in the Quantitative Literacy, Statistical Methods I, and Precalculus Algebra pathways. Instructors specifically worried that students in these three pathways became easily overwhelmed because of the amount of content covered and described how this is one of the possible reasons why students fail or drop the course. At Community College C, they hope to move to a sequential corequisite course model to negate these negative student outcomes. They are also looking at how to alter the Precalculus Algebra sequence so that students do not become overwhelmed in this pathway. An adoption of this alternative course model brings up some important decisions for their department. They must consider if student achievement in the developmental course at the beginning of the semester will affect the placement of students in the gateway course in the second half of the semester (Min & Eugene, 2018; Redl, 2018).

When students are required to sign up for a corequisite course, it could be the first time they have ever heard of corequisite courses. Researchers recognize the importance of making sure that students understand and buy into the corequisite course format so that they are successful (Campbell & Cintron, 2018). Students in this study noted that they were confused and angry when they initially signed up for classes because of the high number of hours they were having to spend in the math classroom. They quickly realized why this was the case and they saw the benefits of taking the corequisite course, but if they had understood the benefits when they initially signed up, this could have improved their attitude at the start of the course. In addition, improving the advising students receive can be an important aspect in creating this student buy-

in. One recommendation from the instructors in this study was that students should be advised to take less classes when they are taking corequisite courses because they can be overwhelming for some students. A recent report from the Center for the Analysis of Postsecondary Readiness suggests that developmental education reforms must be paired with comprehensive institutional reforms, one of which is improving advising for students (Ganga et al., 2018). These improvements can help create a better overall experience for students.

Scott-Clayton et al. (2014) found that approximately 25% of community college students are inaccurately placed into their mathematics course. At three of the community colleges included in this study, students could place into the gateway course without the corequisite, the gateway with the corequisite, or Transition Math. At one college there was no Transition Math, so students took the gateway either with or without the corequisite. Several students and instructors discussed how to increase the accuracy of placement into corequisite courses. Currently, all the colleges in this study are relying on students unweighted high school GPA to place students. One suggestion from a participant in this study was to find students' GPA from their high school math courses. To avoid inaccurate placement of college mathematics students, researchers recommend that colleges implement holistic placement guidelines that consider multiple student measures, including information from a students' high school transcript, ACT or SAT math scores, and placement exams (Campbell & Cintron, 2018; Ganga et al., 2018; Hennessey et al., 2021; Kashyap & Mathew, 2017). To increase placement accuracy, colleges across North Carolina should begin using a combination of measures to determine a students' placement instead of just using students' unweighted high school GPA.

Instructors also discussed the recent removal of Transition Math at Community College B. Instructors were worried about the students who would have previously placed into Transition

Math and thought that these students were being set up to fail by the college because they were never going to be able to keep up with the content in the gateway courses. The requirement that some students pass a foundations math course, Transition Math, before they are allowed to take a corequisite math course is not uncommon (Childers et al., 2021), but this multi-course sequence still puts students at risk of never earning their math credit because of the multiple exit points. Childers et al. (2021) reason that more students should be allowed to take the corequisite course model because they think students have a better chance of passing the corequisite and paired gateway courses than they do in a multi-semester sequence.

Not only should colleges consider attrition concerns when deciding how students are placed into corequisite mathematics courses, but the larger issue of access should also be considered. Students who are required to take developmental mathematics are historically from low-income families, first-generation college students, female, and Black, Native American, or Hispanic students (Bonham & Boylan, 2011; Chen & Simone, 2016). In addition, approximately half of the community college students enrolled in math courses experience a math trap (Ngo & Velasquez, 2020). Thus, colleges should consider the negative implications of requiring multi-semester sequences and should instead consider implementing corequisite courses, since they have been shown by this study to be an effective developmental course model.

A primary goal of corequisite courses is to deliver just-in-time instruction, which means that students review and learn the prerequisite knowledge in their corequisite as they need it to be successful in their gateway course (Atkins & McCoy, 2016; Childers et al., 2021; Kashyap & Mathew, 2017; Mireles et al., 2014). Alignment between the corequisite and gateway course is crucial in ensuring that students are receiving just-in-time instruction, which was described by the students and instructors in this study as a reason why corequisite courses were effective.

Specifically, students claimed they would not have been as successful in their gateway course without the just-in-time learning provided by the corequisite course. One threat to just-in-time learning is the layout of asynchronous gateway and corequisite courses. For example, one student found it challenging to figure out what order assignments should be completed in and they thought having only one Blackboard course would have made a huge difference. Thus, North Carolina community colleges could consider the following suggestions to avoid this confusion from occurring. First, the same instructor should teach asynchronous corequisite and gateway courses. Second, all the necessary math assignments and lectures for the corequisite and gateway course should be in the same online course system (i.e., Blackboard) and in the same online homework tool (i.e., MyMath Lab). This is especially important to ensure just-in-time learning is occurring. Third, if colleges need to have a separate corequisite Blackboard site, it should be used for study skills lessons, extra practice or support that is optional for students, and weekly check ins or reflections to see how students are doing in class and outside of the classroom.

An important decision for colleges and departments when setting up corequisite courses is if there will be one or two instructors teaching the paired corequisite and gateway sections (Childers et al., 2021; Kim, 2016; Redl, 2018). Although, if the developmental and mathematics departments are in different colleges at an institution, then it could be impossible to have the same instructor teach both courses (Atkins & Beggs, 2017, Atkins & McCoy, 2016). When there are two instructors, students experience two different perspectives on the material and a variety of learning styles are supported (Atkins & McCoy, 2016). Having two instructors who teach in varying ways was cited by the participants in this study as being an advantage. In addition, corequisite instructors in this study noticed their students coming to them anytime they had

concerns or issues in their gateway course and how this helped provide students with extra support they might not have received if they had the same instructor. When one instructor taught both sections, colleges have noticed how this helps create cohesiveness between the courses and how this allows instructors to become familiar with students' learning styles (Campbell & Cintron, 2018; Kashyap & Mathew, 2017). Similarly, the instructors in this study liked that when there was one instructor, they were able to see their student's progress throughout both courses and could address issues as they arose more easily. Students especially liked that there was only one teaching style they had to become familiar with and that they only had to communicate with one person. In addition, at Community College A, there was one instructor teaching both courses with all the same students. This allowed for massive amounts of flexibility for the instructor to meet the needs of their students when they needed, which is an important feature of just-in-time instruction. If possible, other colleges should consider adopting this model.

As we mentioned earlier, just-in-time learning is a major characteristic in creating effective corequisite courses. Another threat to this learning is when there are two instructors teaching the corequisite and gateway course and the content they are teaching is not aligned. Frequent communication between instructors can help ensure that there is alignment between the content of both courses (Atkins & Beggs, 2017; Atkins & McCoy, 2016). When there were two instructors, some of the students in this study felt that their two courses were well aligned, while others felt that the communication between their instructors could have been improved. Instructors felt that effective communication between the instructors included having the gateway instructor share their pacing guide at the beginning of the semester and weekly communication about what had been taught and any alterations to the initial course pacing. In addition, corequisite instructors mentioned that they wanted to be added as observers in the

gateway courses' Blackboard sites so they could be aware of what homework was being assigned and any pacing changes that were made. This could assist them in creating more effective lesson plans that aligned to the gateway courses.

One of the biggest threats to just-in-time learning was when Community College B used to pair one corequisite instructor with multiple gateway instructors. Instructors described this course setup as chaotic and explained how when they had up to seven paired gateway instructors it was impossible for them to create lessons that delivered just-in-time learning to all their students. This course setup ensures that students are not receiving the just-in-time learning they need to be successful in their gateway course and ultimately is setting students up for failure. This corequisite course setup where one corequisite instructor is paired with multiple gateway instructors should never be implemented.

Limitations and Future Research

There were a limited number of participants in this study, which meant I was not able to be purposeful in my sampling, specifically, there was a lack of student interview participants from Community College C. In addition, there was an unequal number of participants from each college. Even given these concerns about sampling, I was still able to generate meaningful findings because I was not comparing among institutions, but rather, between instructors and students. In addition, I did not need to interview the same number of participants at each institution to address this comparison between students and instructors. A larger study with more participants would be able to mitigate these concerns and would be able to purposefully select participants to help ensure that the full scope of student and instructor experiences was being explored and would provide the opportunity for comparisons of students and instructors among different community colleges. Future research could also utilize observations of corequisite

courses to triangulate the student and instructor interview data. Despite these limitations, the interview data I collected provides a comprehensive description of corequisite courses in North Carolina community colleges.

Conclusion

The decisions colleges and departments made about how to implement corequisite courses influenced the student and instructor experience. These decisions included the time commitment of corequisite courses, the curriculum and pace of the corequisite and gateway courses, and if there was one or two instructors teaching the corequisite and gateway course pairing. In addition, the classroom level decisions of instructors (i.e., how to teach) and students (i.e., what course modality to take) were explored. The effective teaching practices of instructors were described, however, there were some concerns from students and instructors about asynchronous courses. All suggestions from students and instructors about how to make corequisite courses more effective were about the college and department-level decisions that determined the structure of corequisite courses. Colleges and math departments should consider the suggestions from students and instructors about how to make corequisite courses more effective. Even though students and instructors offered feedback about how to make corequisite courses better, they recommended corequisite courses as an effective developmental mathematics course model. Specifically, students and instructors thought that corequisite courses gave students the opportunity for just-in-time learning and helped them learn, gave students time and space to learn and master the content, and helped students advance through their developmental and mathematics credit efficiently.

CHAPTER 3: A Mixed Methods Approach Investigating Community College Students' Mathematics Beliefs in Corequisite Mathematics Courses

Introduction

At community colleges in North Carolina, the corequisite course model has been implemented in an attempt to reduce exit points for students and redesign the delivery of developmental mathematics. Corequisite courses at these community colleges satisfy a student's developmental math credit and are taken concurrently with a college-level mathematics course, sometimes referred to as a gateway mathematics course. The goal of a corequisite mathematics course is to provide students with the just-in-time instruction necessary for them to excel in their college-level mathematics course.

Research has shown promising findings in support of the corequisite course model (e.g., Atkins & Beggs, 2017; Kashyap & Mathew, 2017; Redl, 2018), but there is still a need to consider the effect of this course model on a students' beliefs. This study investigates students' mindset, math anxiety, and math self-efficacy during a semester-long corequisite mathematics course. In the following section, negative aspects of the traditional developmental mathematics sequence are described. Then, the relevant literature regarding students' mindset, math anxiety, and mathematics self-efficacy is discussed.

Literature Review

The multi-course, traditional developmental mathematics sequence increases the chance that students will either stop taking mathematics courses or drop out of school, when compared to shorter pathways (Vandal, 2014). Thus, a goal of many of the developmental mathematics course redesigns has been to decrease the number of exit points and accelerate students through their mathematics coursework (Atkins & McCoy, 2016). Exit points describe each point in the

program at which a student can exit the developmental mathematics sequence. For example, students could fail or withdraw from the course, they could pass but not enroll in the next course of the sequence, or they may not pass subsequent courses in the sequence.

Chen and Simone (2016) found that developmental mathematics completion rates were inversely related to the number of developmental courses students take, with stark differences between those students who only take one course and those who take four or more. Thus, in extended developmental mathematics sequences, the likelihood that students exit the sequence before ever completing their developmental mathematics requirement increases. Not only does reducing exit points save students time, but it also decreases the financial burden of having to pay for multiple developmental mathematics courses that do not earn a student college-level credit. It has been shown that students who took corequisite courses were able to move through their developmental mathematics and gateway course more efficiently (Atkins & Beggs, 2017; Hennessey et al., 2021) and had greater odds of passing additional mathematics courses compared to their peers in a traditional sequence (Mullins, 2018). The quickened sequence in the corequisite course model helps propel students towards their mathematics credit and a college degree in a timely manner, thus, reducing the risk factors associated with delayed progress, as well as reducing the credit hour and cost burden on students.

Logue et al. (2016) randomly assigned students to three different sequences: developmental Elementary Algebra, developmental Elementary Algebra with an additional weekly workshop, and a college-level Statistics course with a weekly workshop. Those students assigned to the Statistics course were more likely to graduate or transfer to a bachelor's program compared to their peers in the developmental Elementary Algebra sequences. One possible explanation for the difference in graduation rates is the additional exit points in the Elementary

Algebra sequence compared to the sequence for the corequisite Statistics students (Logue et al., 2016). Students who were randomly assigned to Elementary Algebra with an additional weekly workshop were attending five to six hours of class a week and had the worst attrition of all three groups. These students were the furthest from graduation in terms of credit hours of all the groups studied, and Logue et al. (2016) hypothesized that these students were probably the least motivated to attend the course and possibly also college. These results demonstrate the damaging effects of placing students into time consuming developmental mathematics sequences.

Mathematics pathways have been adopted at various universities in accordance with recommendations to create courses that are relevant to student's programs of study (Ganga et al., 2018). Providing students with an opportunity to take a mathematics course relevant to their major can help their motivation to succeed in their mathematics course. In addition to the adoption of various pathways, instructors had several recommendations about how to enhance the corequisite course model. A frequent recommendation was to monitor and grade student attendance because it would encourage students to attend the corequisite lab (Atkins & McCoy, 2016; Campbell & Cintron, 2018). Student attendance at labs was important because students had more opportunities to learn and actively engage with their peers and the content (Kashyap & Mathew, 2017; Kim, 2016). In addition, attending labs meant that some students, depending on the corequisite course model format, were doing math every single weekday. This helped students stay on top of the material and their assignments (Kim, 2016).

Mindset

This dissertation research will draw on Dweck's (2006) definitions of fixed and growth mindset. A fixed mindset causes an individual to believe they only have a certain amount of intelligence. These individuals fear failing because they think a smart individual should always

succeed and setbacks indicate incompetence. In addition, those with a fixed mindset believe that if a task is difficult and requires effort, then they must not be talented or have the necessary ability. On the other hand, an individual with a growth mindset believes they can cultivate their knowledge through their effort and experiences. They believe people work for their success. Individuals with a growth mindset work to increase their intelligence by making learning a priority, specifically they do not shy away from their past mistakes but rather seek to learn from them to better themselves and increase their intelligence.

Over recent years, growth mindset interventions with students have been implemented by researchers. These usually began by teaching students the science and research related to growth mindset, specifically, that their brains are constantly changing and that they can alter their intelligence (Brougham & Kashubeck-West, 2017; Burnette et al., 2018; Hacisalihoglu et al., 2020; Paunesku et al., 2015; Yeager et al., 2016; Yeager et al., 2019), sometimes with specific emphasis on ways to apply the growth mindset theory to schoolwork (Rhew et al., 2018). In addition, Limeri et al. (2020) suggests addressing common misconceptions about IQ and intelligence, as well as, addressing any past academic experiences that could be negatively affecting a student's image of themselves and their mindset.

Researchers have found significant positive increases in growth mindset beliefs following a growth mindset intervention (Brougham & Kashubeck-West, 2017; Burnette et al., 2018; Hacisalihoglu et al., 2020; McCabe et al., 2020). In addition, growth mindset interventions have also resulted in significant increases in middle school special education students' motivation (Rhew et al., 2018) and an increased chance of students taking advance math courses in tenth grade (Yeager et al., 2019). Burnette et al. (2018) found that high school girls' growth mindset significantly predicted their learning motivation, learning efficacy, and grades following an

intervention. Degol et al. (2018) also found that a high school student's mindset predicted their motivational beliefs and that if a student favored a growth mathematical mindset, they also valued math more. In addition, if two high school students of the same socio-economic status were compared, the student with a growth mindset was found to outperform their peer and is more likely to have higher academic achievement (Claro et al., 2016). Overall, researchers have shown the benefits of students possessing a growth mindset, but research is still needed to fully understand developmental mathematics students' mindset and if a corequisite course model can influence this mindset.

Math Anxiety

Mathematics anxiety is a feeling of tension, apprehension, or fear that interferes with an individual's mathematics performance (Ashcraft, 2002). Individuals who suffer from math anxiety avoid math, take fewer elective math courses in high school and college, receive lower grades in math, and hold negative self-perceptions about their math ability. In addition to avoiding math courses, highly anxious math students commonly avoid college majors and career paths that require and depend on mathematical skills. Students with math anxiety tend to speed through their mathematics work, thus minimizing their time spent doing math. Unfortunately, this behavior leads to an increase in student error when completing mathematical problems.

Mathematics anxiety can affect learners at any age. Students in first grade (Maloney & Beilock, 2012) and in community college (e.g., Bitner et al., 1994; Zientek et al., 2010) have reported varying levels of math anxiety. Maloney and Beilock (2012) found that math anxiety in early elementary school can be associated with one or more deficits in the fundamental building blocks of mathematics. In addition, if mathematics anxiety levels are not addressed prior to students entering college, then the middle and high school students who exhibit high levels of

anxiety may be the students who are required to take developmental mathematics when they start college (Zientek et al., 2010). When students have had years to embed mathematics anxiety within their belief system about their ability to do math, it can be challenging for students to overcome and succeed in their college-level mathematics course.

The relationship between mathematics anxiety and academic performance was investigated among developmental mathematics students at a community college (Raju, 2018). Students in this study expressed that they found safety in numbers by turning to outside help, Google, friends, tutors, or their teacher. The origin of students' math anxiety reflected a broad range of concerns, such as, formulas, tests, a lack of preparation, and missing the basic idea of a problem. The hardest or most challenging parts of math class for these students was when they were asked to solve word problems and when they failed to understand how the numbers worked in the problem.

When a mathematics anxiety intervention was implemented in mathematics courses at a community college, the experimental students had significantly lower math anxiety at the end of the semester compared to their peers in the control condition (Bitner et al., 1994). In addition, students throughout the study made comments that indicated their lack of confidence in their mathematical ability due to their own self-perceptions. Nicoloff (2018) examined the relationship between students' math anxiety and their math self-efficacy, and math anxiety was found to be a significant negative predictor. Thus, students with high levels of math anxiety had low mathematics self-efficacy. Campbell (2015) found that students in a corequisite mathematics course expressed anxiety over taking a math course at the beginning of the semester, but by the end of the semester, students gained confidence in their math ability and began to think of their math course as an enjoyable experience. Overall, a student's confidence in their math ability and

their math anxiety have been found to relate to one another. This study will also address these two factors, while analyzing a third, a student's mindset.

Math Self-Efficacy

Self-efficacy can be defined as the belief in one's abilities to perform actions needed to produce a given result (Bandura, 1997). Thus, mathematics self-efficacy can be defined as one's confidence in their ability to do math. Findings from a mathematics self-efficacy pre- and post-survey of corequisite and traditional developmental mathematics students indicated a significant increase in mathematics self-efficacy in corequisite students, but not for students in a traditional developmental math sequence (Kim, 2016). In addition, attendance rates for corequisite students were significantly higher, and they claimed to be more satisfied by the course (Kim, 2016). Even though community college students often possess negative attitudes regarding their ability to do well in school, corequisite mathematics courses can positively impact students' mathematics self-efficacy.

Students who are actively engaged in the course material and in their learning are more likely to have higher self-efficacy (Bandura, 1997). A mathematics attitudes pre- and post-survey showed that students in a corequisite Statistics course showed significant increases on the interest, growth, and utility domains compared to students in a traditional, developmental mathematics course who only showed an increase in the interest domain (Logue et al., 2016). The authors theorized two possible explanations for these results, that the Statistics students were more likely to form self-initiated study groups and were more likely to attend their accompanying workshop (Logue et al., 2016). Findings from a survey about the corequisite and traditional course models revealed that corequisite students expressed a higher level of enthusiasm toward the learning process and were more actively engaged in the classroom

(Kashyap & Mathew, 2017). Evidence exists in support of attendance and participation policies for students in corequisite courses (Kim, 2016; Logue et al., 2016) and demonstrates how students who are placed into college-level courses instead of a traditional, developmental course sequence can be more motivated, have positive attitudes about math, and increased self-efficacy (Kashyap & Mathew, 2017; Kim, 2016; Logue et al., 2016).

Students who were placed into the traditional developmental mathematics sequence instead of a college-level course felt like the developmental course was a setback and were disappointed by their placement in this course (Kashyap & Mathew, 2017). These students did not exhibit confidence or motivation, were more likely to be disengaged in class, and were not interested in the material since they had been exposed to the same content in high school. Whereas the students in the corequisite model appreciated the content in the corequisite course because they were simultaneously applying this knowledge in their gateway course. Overall, approximately 80% of the students taking either a corequisite or traditional developmental mathematics course favored the corequisite course model and 30% favored the traditional course sequence (Kashyap & Mathew, 2017). These results lend support to the replacement of the traditional developmental mathematics sequence with corequisite courses.

Research has shown the negative effects of extended traditional developmental mathematics sequences (Chen and Simone, 2016; Vandal, 2014) and positive benefits of the corequisite course model (Atkins & Beggs, 2017; Kim, 2016; Logue et al., 2016). But there is a lack of research investigating the effects of the corequisite course model on student beliefs. This study will expand upon the research exploring math anxiety and math self-efficacy (e.g., Campbell, 2015), by also investigating students' mindset. This study uses qualitative and quantitative data to investigate if corequisite mathematics students' mindset, math anxiety, and

math self-efficacy change over the course of a semester, how and if this change is related to a student's satisfaction with their final grade, and how the corequisite course model influenced this potential change in mindset, math anxiety, and math self-efficacy.

Methodology

The intent of this study was to learn about the impact of the corequisite course model on students' mindset, math anxiety, and math self-efficacy. A convergent parallel mixed methods design was used, in which qualitative and quantitative data were collected in parallel, analyzed separately, and then merged (Creswell & Plano Clark, 2018). In this study, pre- and post-survey data measured the change in students' mindset, math anxiety, and math self-efficacy and their satisfaction with their final grade, while semi-structured interviews with community college students investigated the influence of the corequisite course model on their mindset, math anxiety, and math self-efficacy. Once the survey and interview data were summarized separately, the merged results explored the influence of the corequisite course model on students' mindset, math anxiety, and math self-efficacy. In the next sections, the research questions, study participants, data collection process, data analysis procedures, and my positionality will be described.

Research Questions

This study will be guided by the following research questions:

2. How do the corequisite courses at a community college impact students' mindset, math anxiety, and math self-efficacy?
    a. Are there significant differences between students' initial and post mindset, math anxiety, and math self-efficacy?

b. Are there differences between the change in students' mindset, math anxiety, and math self-efficacy given their satisfaction with their final grade?
c. In what ways does the corequisite course influence students' mindset, math anxiety, and math self-efficacy?

Participants

The mathematics department heads from nine of the largest community colleges, all in urban areas, in North Carolina were emailed and asked if they would be willing to participate in my study. These community colleges were purposefully selected due to their demographic similarities. Four colleges, which I will refer to as community college A, B, C, and D, agreed to participate. Corequisite courses were implemented in the spring of 2019 at Community College B, in the fall of 2019 for Community Colleges A and D, and in the fall of 2020 at Community College C. All North Carolina community colleges utilize the same course objectives for the five course pathways, Math Measurement and Literacy, Algebra/Trigonometry I, Quantitative Literacy, Statistical Methods I, and Precalculus Algebra. Data was collected in the spring of 2022 at Community College D and in the fall of 2022 at all four community colleges.

All instructors teaching corequisite courses were sent an email asking them to recruit their corequisite students to participate in this study, which included completing a pre-survey, post-survey and an interview. Instructors across the four colleges who participated in the student recruitment and data collection in this study asked all of their students to complete a pre- and post-survey. In the survey, students indicated if they were willing to complete an interview. In the spring of 2022, six students volunteered to be interviewed, but only three completed an interview. In the fall 2022 semester, 56 students volunteered to be interviewed. Fourteen students scheduled interviews but only eight completed an interview. As a result of the limited number of

participants, I did not purposefully select interview participants. Instead, I interviewed every student who volunteered. The number of student participants who completed the pre-survey, post-survey, both the pre- and post-survey, and interview is detailed in Table 6. The community college each student interview participant attended and the course pathway and modality they took are detailed in Table 7.

Table 6

Number of Student Survey and Interview Participants

College	Semester Data Collected	Pre-Survey Participants	Post-Survey Participants	Complete Survey Data	Interview Participants
A	Fall 2022	34	13	8	2
B	Fall 2022	49	27	13	2
C	Fall 2022	12	16	4	0
D	Spring 2022	32	17	5	3
	Fall 2022	47	22	17	4
Total		174	95	47	11

Table 7

Overview of Student Interview Participants

College	Participant Pseudonym(s)	Course Modality	Course Pathway
A	Jasmine, Jose	Asynchronous	Quantitative Literacy
B	Cameron	In-person	Quantitative Literacy
	Nate	In-person	Algebra/Trigonometry I
D	Nick	Asynchronous	Precalculus Algebra
	Aaron, Ethan, Jackson, Rebecca	In-person	Precalculus Algebra
	Kaden	In-person	Quantitative Literacy
	Shanelle	In-person	Statistical Methods I

Data Collection

In this section the pre- and post-survey administration and the constructs being measured in the survey are discussed. Then, the interview procedure is explained, and the interview protocol is described.

Student Pre- and Post-Survey

At the start and end of the Spring and Fall 2022 semesters, corequisite mathematics instructors were emailed and asked to facilitate a pre-survey (see Appendix E) and a post-survey (see Appendix F) to their students. The email explained the purpose of this study, asked instructors to read a brief overview of this study to their students, and provided the survey link for them to share with their class. Follow-up emails were sent to remind instructors to share the survey with their students. Only students 18 years old and older could complete the surveys. The pre- and post-surveys were administered via Qualtrics and asked students for their name, the course they were taking, their course section number, and the modality of their corequisite course. In addition, the survey asked questions that measured their mindset, math anxiety, math self-efficacy and grade satisfaction. Each of these constructs and the questions used to measure them are described below.

Mindset. Dweck et al. (1995) proposed a 3-item, 6-point Likert scale measure to gauge whether a respondent held a fixed or growth mindset. The three items are: (a) “You have a certain amount of intelligence, and you really can’t do much to change it”; (b) “Your intelligence is something about you that you can’t change very much”; and (c) “You can learn new things, but you can’t really change your basic intelligence” (Dweck et al., 1995, p. 269). The survey included two versions of this measure, a version that measured mindset about their general intelligence as stated above and a version that measured mathematical mindset. The version that measured a student’s mathematical mindset asks the same three questions with the addition of “math” in front of intelligence. Research has shown that students could possess a growth mindset in terms of their general intelligence but a fixed mathematical mindset (Shively & Ryan, 2013), so both were measured to see if there was a significant difference. The score of the three general

and the three math mindset items were averaged to form an overall general and math mindset score, with higher scores indicating a stronger growth mindset. Participants with scores of three or below are considered to have a fixed mindset and those who score a four or above were classified as having a growth mindset (Dweck et al., 1995).

This measure was found to be a reliable and valid measure of participants' mindset (Dweck et al., 1995). Dweck and colleagues showed that this measure had a high internal reliability, alpha ranged from 0.94 to 0.98, and had strong test-retest reliability, 0.80, over a two-week period. The measure is independent of a respondents' sex, age, political affiliation, and religion. As well as being unrelated to measures of an individual's cognitive ability, confidence in intellectual ability, self-esteem, and optimism.

Math Anxiety. Students' math anxiety is measured by the Single-Item Math Anxiety Scale (SIMA) developed by Ashcraft (2002) that asks, "On a scale from one to ten, how math anxious are you?" A response of one indicates a student is not anxious and ten indicates a student is very anxious. For the SIMA score, lower values represented students with less math anxiety. Scores four or less were classified as low math anxiety and scores of seven or greater were classified as high math anxiety. This scoring classification was constructed this way to minimize the number of students labeled moderate anxiety to only be the students who selected the middle two points on the scale.

This is a valid and reliable measure for assessing participants' math anxiety (e.g., Nunez-Pena et al., 2014). The SIMA scale was selected so as not to overload students with an unnecessarily long survey, such as the 98-item Math Anxiety Rating Scale (MARS; Richardson & Suinn, 1972), that could have resulted in fatigue in respondents and ultimately poor data. Nunez-Pena et al. (2014) administered the SIMA and the Shortened Mathematics Anxiety Rating

Scale (sMARS; Alexander & Martray, 1989) to 279 university students to evaluate the relationship of the scores of these two measures. A strong positive correlation between the scores of the SIMA and sMARS existed, $r = 0.77$. The test-retest reliability for SIMA, 0.81, was also calculated and these results showed that the SIMA displayed adequate test-retest reliability over a 7-week period (Nunez-Pena et al., 2014). These results provide adequate evidence for the reliability of the SIMA scale.

Math Self-Efficacy. The Confidence in Learning Mathematics Scale (CLMS) is a part of the Fennema-Sherman Mathematics Attitudes Scales (1976) and measures a student's confidence in their ability to learn and perform well on mathematical tasks. This 12-item, 6-point Likert scale was used to measure students' mathematics self-efficacy. The scale consists of 6 items which reflect a positive affective view (i.e., "I am sure I could do advanced work in mathematics.") and 6 items which reflect a negative affective view (i.e., "I'm no good at math."). Half of the items were reverse coded and then all the items were averaged to create an overall score. Since the CLMS and mindset measures are both six-point scales, the same classification score cutoffs that were used for the mindset scores were used for participant math self-efficacy scores. Thus, participants with scores of three or below are considered to have low math self-efficacy and those who score a four or above were classified as having high math self-efficacy.

Broadbooks et al. (1981) administered the Fennema-Sherman Mathematics Attitudes Scales to 1,541 junior high school students and found evidence to support the theoretical structure of the scales, specifically that each of the Fennema-Sherman scales measured different constructs that makeup a participants' mathematical attitude. Thus, the CLMS can be administered separate from the other Fennema-Sherman Mathematics Attitudes Scales and still be considered a reliable measure of a students' mathematics self-efficacy. In addition, Wikoff

and Buchalter (1986) showed the CLMS has a high internal reliability, 0.95, and can be generalized to college populations.

Grade Satisfaction. On the post-survey students were asked to self-report the final letter grade they expected to earn and rate how satisfied they are with their expected grade on a scale of one to ten with ten indicating they are very satisfied. These questions were asked to gage students' perceived success in the course. For example, a student who is used to making A's in math could be unhappy with a C as their final grade, while a student who is used to struggling in math could be very satisfied with a C as their final grade. For the analysis, students were split into three groups, those who reported being satisfied with their grade (values ranging from seven to ten), those who were neutral (values ranging from five to six), and those who were not satisfied (values ranging from one to four). Similar to the math anxiety score classification, only the middle two values on the grade satisfaction scale were classified as neutral in an effort to only capture the students who scored in the middle on the scale.

Student Interviews

Interviews were scheduled for the end of the semester so that students could be asked if they had noticed a change in their beliefs due to the corequisite course model compared to their previous experiences in mathematics classrooms. The interviews were semi-structured, audio recorded via Zoom, and lasted between thirty minutes to an hour. Students were compensated for their time with a $15 Amazon gift card. Interview questions asked students about any concerns they had when they signed up for a corequisite mathematics course, how they feel about math, and if their beliefs changed over the course of the semester. Interviews were transcribed by the researcher. See Appendix G for the student interview protocol.

Data Analysis

Student Pre- and Post-Survey

The survey results were used to calculate a score for each of the four constructs, general mindset, math mindset, math anxiety, and math self-efficacy. A post-survey minus pre-survey gain score was calculated for each construct and depicted the change in student's mindset, math anxiety, and math self-efficacy from the beginning to the end of the semester. A positive mindset gain score indicated a student's mindset increased toward the growth mindset end of the scale. A negative SIMA gain score meant that a student's math anxiety decreased over the course of the semester. A positive CLMS gain score meant a student's math self-efficacy increased.

Testing for Changes in Students' Mindset, Math Anxiety, and Math Self-Efficacy. Paired t-tests were computed for the general intelligence mindset, mathematical mindset, SIMA, and CLMS scores to determine if there was a significant change in students' mindset, math anxiety, or math self-efficacy from the beginning to the end of the course. In addition, paired t-tests were computed to compare students' general intelligence mindset and their mathematical mindset for statistically significant differences between the pre-scores, post-scores, and gain scores. This analysis seeks to discover if students' general mindset differed significantly compared to their mathematical mindset at any point during the semester.

Testing for Differences Between Colleges, Courses, and Course Modalities. Data was collected at four different community colleges and across different course pathways for the corequisite courses. The pre-scores, post-scores, and gain scores for students' mindset, math anxiety, and math self-efficacy were compared across each of these groups to determine if students at different colleges who were taking different courses had significantly different beliefs. When the pre-scores, post-scores, or gain scores were normally distributed and there was

equal variance between the groups, ANOVA analyses were used to test if the means of the independent groups were significantly different. Bonferroni's post hoc test was used to find the significant differences between the groups when the ANOVA analysis indicated there was a significant difference. If the pre-scores, post-scores, or gain scores were not normally distributed or there was not equal variance between the groups, the non-parametric Kruskal-Wallis Test was used to determine whether the medians of the independent groups were significantly different. See Table 8 for a summary of when ANOVA analyses and Kruskal-Wallis Tests were used. Note that no student in the completed dataset was taking Math Measurement & Literacy and only one student was taking Algebra/Trigonometry I, so these two course pathways were not included in the analysis.

Differences in students' beliefs between those who enrolled in each course modality was also analyzed. There were only two course formats, in-person and asynchronous, represented in the complete data set. Thus, a Two Sample *t*-test with equal variance was used to test for significant differences between the mean pre-scores, post-scores, and gain scores for the two course modalities when the data was normally distributed and there was equal variance. When the data was normally distributed but there was not equal variance between the two groups, a Two Sample *t*-test with unequal variance was used. If the scores were not normally distributed, the non-parametric Wilcoxon Rank Sum Test was used to determine if there were differences in median mindset, math anxiety, and math self-efficacy scores between the students taking an in-person and asynchronous class. See Table 8 for a summary of when each test was used.

Testing for Differences Given Student Grade Satisfaction. On the post-survey, students rated their satisfaction with their final grade on a scale from one (not satisfied) to ten (satisfied). Students were split into three groups, those who reported being satisfied with their

Table 8

Statistical Test Used to Measure Differences Between Colleges, Courses, and Course Modality

	Group Being Compared		
	Community Colleges (n = 4)	Courses (n = 3)	Course Modality (n = 2)
General Mindset			
Pre-Score	Kruskal-Wallis Test	Kruskal-Wallis Test	Wilcoxon Rank Sum Test
Post-Score	Kruskal-Wallis Test	Kruskal-Wallis Test	Two Sample *t*-test (equal variance)
Gain Score	ANOVA	ANOVA	Two Sample *t*-test (equal variance)
Math Mindset			
Pre-Score	Kruskal-Wallis Test	Kruskal-Wallis Test	Wilcoxon Rank Sum Test
Post-Score	Kruskal-Wallis Test	Kruskal-Wallis Test	Two Sample *t*-test (equal variance)
Gain Score	ANOVA	ANOVA	Two Sample *t*-test (unequal variance)
Math Anxiety			
Pre-Score	Kruskal-Wallis Test	Kruskal-Wallis Test	Two Sample *t*-test (equal variance)
Post-Score	ANOVA	ANOVA	Two Sample *t*-test (equal variance)
Gain Score	ANOVA	ANOVA	Two Sample *t*-test (unequal variance)
Math Self-Efficacy			
Pre-Score	ANOVA	ANOVA	Two Sample *t*-test (equal variance)
Post-Score	Kruskal-Wallis Test	ANOVA	Two Sample *t*-test (equal variance)
Gain Score	ANOVA	ANOVA	Two Sample *t*-test (equal variance)

grade (values ranging from seven to ten), those who were neutral (values ranging from five to six), and those who were not satisfied (values ranging from one to four). ANOVA analyses were conducted to determine if there were significant differences in students' mindset, math anxiety, and math self-efficacy post-scores based on their grade satisfaction. Bonferroni's post hoc test was used to find the significant differences between the groups when the ANOVA analysis

indicated there was a significant difference. Grade satisfaction was not analyzed in relation to participants pre-survey or gain scores because grade satisfaction was an outcome of the course and was not expected to have any relation to a student's beliefs at the start of the semester.

Student Interviews

This study analyzed the effects of corequisite courses on student mindset, math anxiety, and math self-efficacy, thus, the interview transcripts were coded to capture what features of the corequisite course impacted these beliefs. Based on the literature, such features include: (a) time spent in the course (Atkins & Beggs, 2017; Childers et al., 2021; Hennessey et al., 20217; Kim, 2016); (b) attendance and participation requirements (Atkins & Beggs, 2017; Kashyap & Mathew, 2017; Kim, 2016; Logue et al., 2016); and (c) just-in-time learning (Atkins & Beggs, 201; Hennessey et al., 20217; Kashyap & Mathew, 2017). The influence of these three features on mindset, math anxiety, and math self-efficacy served as a basis for the codebook. Inductive in vivo coding (Saldaña, 2013) was also used to capture an additional feature described by students, the influence of various course modalities, as well as any additional comments made by students about how they felt when signing up for a corequisite course. These two additional codes helped provided a clearer picture of students in corequisite courses. A codebook was created with carefully constructed code descriptions (see Appendix H). A second researcher helped code twenty percent of the student interviews, which resulted in 88.48% agreement. This established the codebook and clarity of the code descriptions.

Converging the Results

In a parallel convergent mixed methods design, the quantitative and qualitative data is collected and analyzed separately, before being merged and analyzed collectively (Creswell & Plano Clark, 2018). To help ensure trustworthiness of the results, multiple data sources were

merged, the student interviews, student pre- and post-surveys, and memos written during the data collection and data analysis process. In this study, the quantitative data measured the change in students' mindset, math anxiety, and math self-efficacy and the relationship of these constructs with a students' grade satisfaction. The qualitative data explored the influence of the corequisite course model on students' mindset, math anxiety, and math self-efficacy. The survey and interview results were compared, contrasted, and synthesized in order to create a comprehensive understanding of the influence of the corequisite course model on students. During this synthesis, student pre-survey responses were compared to student comments from the interviews about their mindset, math anxiety, and math self-efficacy prior to the start of the course. In addition, the change in a student's mindset, math anxiety, and math self-efficacy based off their survey results was compared to the comments they made about how their beliefs changing due to the corequisite course during the interview.

Positionality

I am a White, monolingual, cisgender woman in her late twenties who has been a high school teacher and an adjunct instructor at a community college in North Carolina. I interviewed students with diverse backgrounds, which could have impacted my interactions with them during the interviews. Some of the student interview participants might have viewed me as an authority figure given my past teaching experience, but this dynamic might not have been true among all students since some were older than me. In addition, my background as a community college adjunct instructor inevitably influenced my approach to this study and my interactions with participants. I have taught Quantitative Literacy at the community college level and Precalculus at the high school level, which ultimately makes me more familiar with the curriculum in these courses compared to the other course pathways. To make sure this familiarity with topics

covered in Quantitative Literacy and Precalculus did not impact my interviews with students and instructors, I reviewed the course descriptions at each college for each of the five course pathways. This helped ensure I fully understood the curriculum covered in each course. Overall, I hope that since I am not connected to their college in any way, that students were able to feel comfortable sharing their experience about taking a corequisite mathematics course and how this course may or may not have impacted their mindset, math anxiety, or math self-efficacy.

Findings

Quantitative Results

Results from paired *t*-tests comparing the pre and post general mindset, mathematical mindset, math anxiety, and math self-efficacy scores are shown in Table 9. Students' general mindset significantly decreased ($t = -2.16, p = 0.0181$) from the beginning ($\mu = 4.63\ , \sigma = 1.20$) to the end ($\mu = 4.37, \sigma = 1.41$) of the semester. Students had significantly lower general growth mindset at the end of the semester than they did at the beginning of the semester. Similarly, students' mathematical mindset decreased from the beginning ($\mu = 4.60, \sigma = 1.15$) to end ($\mu = 4.49, \sigma = 1.20$) of the semester, but this decrease was not significant ($t = -0.88, p = 0.1908$). Students had slightly lower math growth mindset at the end of the semester than they did at the beginning of the semester. Students' math anxiety at the end of the course ($\mu = 5.26, \sigma = 2.57$) was lower, but not statistically significant, ($t = -1.56, p = 0.0624$) than students' math anxiety at the beginning of the course ($\mu = 5.72, \sigma = 2.61$). In addition, students' CLMS pre-scores ($\mu = 3.76\ , \sigma = 1.08$) significantly increased ($t = 1.96, p = 0.0279$) compared to their post-scores ($\mu = 3.95\ , \sigma = 1.16$). This indicates students' math self-efficacy significantly increased over the course of the semester.

Table 9

Paired t-tests Results Comparing Student Pre-Survey and Post-Survey Results

Belief Measured by the Survey	Type of Score (n = 47)	Mean	Standard Deviation	*t*
General Mindset	Pre-Score	4.63	1.20	-2.16*
	Post-Score	4.37	1.41	
Math Mindset	Pre-Score	4.60	1.15	-0.88
	Post-Score	4.49	1.20	
Math Anxiety	Pre-Score	5.72	2.61	-1.56
	Post-Score	5.26	2.57	
Math Self-Efficacy	Pre-Score	3.76	1.08	1.96*
	Post-Score	3.95	1.16	

Note: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Results from paired *t*-tests comparing the general and mathematical mindset pre-scores, post-scores, and gain scores are shown in Table 10. There was a difference in the mean general mindset pre-scores ($\mu = 4.63, \sigma = 1.20$) and the mathematical mindset pre-scores ($\mu = 4.60, \sigma = 1.15$), but this difference was not significant ($t = 0.32, p = 0.7471$). On the post-test, there was not a significant difference ($t = -1.27, p = 0.2098$) in the mean general mindset ($\mu = 4.37, \sigma = 1.41$) and mathematical mindset scores ($\mu = 4.49, \sigma = 1.20$). The general mindset gain score ($\mu = -0.26, \sigma = 0.83$) decreased more than the mathematical mindset gain score ($\mu = -0.11, \sigma = 0.83$), but this difference was not significant ($t = -1.46, p = 0.1506$).

Table 10

Paired t-tests Results Comparing Students' General and Mathematical Mindset

Type of Score (n = 47)	Belief Measured by the Survey	Mean	Standard Deviation	*t*
Pre-Score	General Mindset	4.63	1.20	0.32
	Math Mindset	4.60	1.15	
Post-Score	General Mindset	4.37	1.41	-1.27
	Math Mindset	4.49	1.20	
Gain Score	General Mindset	-0.26	0.83	-1.46
	Math Mindset	-0.11	0.83	

Note: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$

Next, differences in student's pre-scores, post-scores, and gain scores between the four community colleges are discussed. Descriptive statistics for each score broken down by each college is shown in Table 11. Results from ANOVA analyses show that there are not significant differences between the four colleges in mean math self-efficacy pre-scores, math anxiety post-scores, general and mathematical mindset gain scores, and math self-efficacy gain scores. Similarly, Kruskal-Wallis Tests indicate that there are not significant differences between the four colleges in median general and mathematical mindset pre-scores, math anxiety pre-scores, general and mathematical mindset post-scores, and math self-efficacy post scores. An ANOVA showed significant differences in the mean math anxiety gain score across the four community

Table 11

Descriptive Statistics of Pre, Post, and Gain Scores by College

	Community College A (n = 8)		Community College B (n = 13)		Community College C (n = 4)		Community College D (n = 22)	
	μ	σ	μ	σ	μ	σ	μ	σ
General Mindset								
Pre-Score	4.04	1.01	4.87	1.20	3.92	1.17	4.83	1.22
Post-Score	4.00	1.36	4.36	1.44	3.92	1.20	4.59	1.48
Gain Score	-0.04	0.90	-0.51	1.01	0.00	0.86	-0.24	0.70
Math Mindset								
Pre-Score	4.25	0.90	4.85	1.08	4.00	0.47	4.68	1.33
Post-Score	4.17	1.26	4.51	1.30	3.75	0.83	4.73	1.17
Gain Score	-0.08	0.64	-0.33	1.11	-0.25	0.50	0.05	0.74
Math Anxiety								
Pre-Score	7.00	2.07	5.62	3.31	6.75	4.27	5.14	1.86
Post-Score	6.13	2.10	4.00	2.71	7.50	3.00	5.27	2.31
Gain Score	-0.88	1.25	-1.62	1.98	0.75	1.50	0.14	2.14
Math Self-Efficacy								
Pre-Score	3.03	0.59	4.08	1.03	3.08	1.16	3.95	1.12
Post-Score	3.34	0.91	4.40	1.02	3.19	1.92	4.03	1.08
Gain Score	0.31	0.61	0.31	0.86	0.10	0.80	0.08	0.51

colleges ($F = 2.88, p = 0.0468$), but Bonferroni's post hoc test did not find any significant differences in mean math anxiety gain scores between the four colleges.

Differences in students' pre-scores, post-scores, and gain scores between the three course pathways was also analyzed. Descriptive statistics for each score broken down by course pathway is shown in Table 12. ANOVA analyses show that there are not significant differences between the three course pathways in mean math self-efficacy pre-scores, math anxiety post-scores, math self-efficacy post-scores, general and mathematical mindset gain scores, and math self-efficacy gain scores. Likewise, results from the Kruskal-Wallis Test shows there are not significant differences between the three course pathways in median general and mathematical mindset pre-scores, math anxiety pre-scores, and general and mathematical mindset post-scores.

Table 12

Descriptive Statistics of Pre, Post, and Gain Scores by Course Pathway

	Quantitative Literacy (n = 18)		Statistical Methods I (n = 10)		Precalculus Algebra (n = 18)	
	μ	σ	μ	σ	μ	σ
General Mindset						
Pre-Score	4.41	1.20	4.87	1.08	4.69	1.31
Post-Score	4.06	1.40	4.87	1.08	4.37	1.58
Gain Score	-0.35	1.03	0.00	0.59	-0.31	0.77
Math Mindset						
Pre-Score	4.44	1.02	4.87	1.01	4.57	1.39
Post-Score	4.22	1.28	5.07	0.62	4.39	1.31
Gain Score	-0.22	0.97	0.20	0.63	-0.19	0.78
Math Anxiety						
Pre-Score	6.39	2.66	5.10	1.45	5.61	2.95
Post-Score	4.94	2.34	5.90	1.66	5.44	3.09
Gain Score	-1.44	1.79	0.80	1.55	-0.17	2.20
Math Self-Efficacy						
Pre-Score	3.37	0.90	3.95	1.08	3.95	1.18
Post-Score	3.74	1.00	4.06	1.09	3.99	1.33
Gain Score	0.36	0.72	0.11	0.55	0.03	0.63

An ANOVA showed significant differences in the mean math anxiety gain score across the three course pathways ($F = 4.73, p = 0.0139$). Bonferroni's post hoc test found significant differences in mean math anxiety gain scores between students taking Statistical Methods I and Quantitative Literacy corequisite courses ($t = 2.96, p = 0.015$). This result suggests that students taking Quantitative Literacy had larger decreases in their math anxiety ($\mu = -1.44, \sigma = 1.79$) compared to their peers taking Statistical Methods I who saw an increase in their math anxiety ($\mu = 0.8, \sigma = 1.55$) over the course of the semester.

Students taking an in-person class were compared to those taking an asynchronous corequisite class. Descriptive statistics for each score broken down by course modality is shown in Table 13. Two Sample *t*-tests with equal variance determined that there are not significant

Table 13

Descriptive Statistics of Pre, Post, and Gain Scores by Course Modality

	Asynchronous (n = 16)		In-Person (n = 26)	
	μ	σ	μ	σ
General Mindset				
Pre-Score	4.33	1.07	4.74	1.33
Post-Score	4.33	1.30	4.22	1.55
Gain Score	0.00	0.83	-0.53	0.82
Math Mindset				
Pre-Score	4.54	0.96	4.53	1.32
Post-Score	4.33	1.17	4.46	1.30
Gain Score	-0.21	0.61	-0.06	1.00
Math Anxiety				
Pre-Score	6.31	3.18	5.54	2.39
Post-Score	6.00	2.90	4.81	2.45
Gain Score	-0.31	1.40	-0.73	2.44
Math Self-Efficacy				
Pre-Score	3.43	1.07	3.82	0.98
Post-Score	3.61	1.29	4.03	1.07
Gain Score	0.18	0.70	0.21	0.68

differences between the two course formats in mean math anxiety pre-scores, math self-efficacy pre-scores, general and mathematical mindset post-scores, math anxiety post-scores, math self-efficacy post-scores, general mindset gain scores, and math self-efficacy gain scores. Two Sample *t*-tests with unequal variance found that there are not significant differences between the two course formats in mean mathematical mindset and math anxiety gain scores. The Wilcoxon Rank Sum Test showed that there are not significant differences between the course formats in the median general and mathematical mindset pre-scores. Thus, those students taking in-person corequisite courses did not differ from those taking asynchronous corequisite courses.

Finally, ANOVA analysis tested for differences in student's mindset, math anxiety, and math self-efficacy post-scores based on their grade satisfaction. Descriptive statistics for each score broken down by grade satisfaction is shown in Table 14. Students were placed into three groups, not satisfied, neutral, and satisfied. There are not significant differences between the grade satisfaction groups in mean general and mathematical mindset post-scores. There were significant differences in the mean math self-efficacy post-scores ($F = 8.58, p = 0.0007$) across the three grade satisfaction groups. Bonferroni's post hoc test found a significant difference ($t = 2.71, p = 0.029$) in mean math self-efficacy post-score between those students who were not

Table 14

Descriptive Statistics of Post-Scores by Grade Satisfaction

	Not Satisfied (n = 10)		Nuetral (n = 6)		Satisfied (n = 30)	
	μ	σ	μ	σ	μ	σ
General Mindset	3.70	1.31	4.33	1.71	4.58	1.38
Math Mindset	3.93	1.13	4.67	0.92	4.62	1.27
Math Anxiety	6.90	2.88	3.17	2.48	5.13	2.24
Math Self-Efficacy	2.77	1.01	4.19	0.88	4.29	1.04

satisfied by their grade ($\mu = 2.77, \sigma = 1.01$) and those who felt neutral about their grade ($\mu = 4.19, \sigma = 0.88$). Additionally, students who were satisfied with their final grade ($\mu = 4.29, \sigma = 1.04$) had a significantly higher ($t = 4.09, p = 0.001$) mean math self-efficacy compared to students who were not satisfied with their grade ($\mu = 2.77, \sigma = 1.01$). There were also significant differences in mean math anxiety post-scores ($F = 4.59, p = 0.0156$) across the three grade satisfaction groups. Bonferroni's post hoc test found that students who felt neutral about their grade ($\mu = 3.17\ \sigma = 2.48$) had a significantly lower ($t = -2.99, p = 0.014$) mean math anxiety compared to students who were not satisfied with their grade ($\mu = 6.9, \sigma = 2.88$).

Qualitative Results

Understanding how students felt at the beginning of the semester and in past mathematics classrooms is an important step in understanding how students began their corequisite course and ultimately if and how their mindset, math anxiety, and math self-efficacy were influenced over the course of the semester. Thus, student interview responses can be split into two major themes: (1) how students felt at the beginning of the semester when they signed up for a corequisite course; and (2) how the characteristics of corequisite courses influenced their mindset, math anxiety, or math self-efficacy.

How Students Felt at the Beginning of the Semester

To fully comprehend how students' mindset, math anxiety, or math self-efficacy could have changed over the course of the semester, it is imperative to understand what beliefs and experiences related to math students had when the corequisite course began. See Table 15 for an overview of how students feel about math, their concerns when they signed up for a corequisite course, and if they were excited when they signed up for a corequisite course.

Table 15

How Students Felt at the Beginning of the Semester

	Number of Students	Quotes from Students
Positive feelings about math	3	I like math. That is my best subject...I just love math compared to the other, out of the four main ones [math, English, science, and history]. I have to put math at the top for me. Math is useful in everyday life, especially if you're going to be an adult. So I find it useful and interesting sometimes to like to use math.
Negative feelings about math	9	I have been doing my best to avoid math. I don't like math. I'm not a math person. Back then, I used to really despise math, I would say. I never really liked it. Like it wasn't that I hated it…but I really just did not like it because it needed a lot of time and a lot of calculations and I just, I guess I was not ready for that.
Worries or concerns when they signed up for the corequisite	11	Yeah. I was pretty stressed at first just because it had been so long since I had taken a math class. Yeah. It was just because of how much time I'd spent away from math. I was like, I don't know if I can do this. Like I was already like trying to figure out how to correctly withdrawal from classes or drop them, I was scared. I think I did [have concerns], but I think that was just possibly myself prioritizing time to study. Yeah, just myself, just time management, that's all.
If they were excited when they signed up for the corequisite	3	To like take the class in general, I was definitely more excited. Because I wanted, it's something that I really wanted to be good at, calculus. It's something that I've always found fascinating... knowing myself, I will not reach out for help. So like having that support class it's like, okay, you're forced to reach out for help because we're going to make a whole class around help.

Influence of the Corequisite Course

The influence of the features of a corequisite course on a student's mindset, math anxiety, and math self-efficacy was described by students through comments about the time spent in the corequisite course, their view of attendance and participation requirements, the effect of just-in-time learning, and their opinion of various course modalities. Each of these codes is described in more detail below.

Time Spent in the Course. Nine out of the 11 students discussed the advantage of having extra time to do math in the corequisite course, which is something they would not have had if they were just taking a gateway mathematics course. Two of these students, Nick and Shanelle, did not speak about how the time spent in the corequisite course specifically influenced their mindset, math anxiety, or math self-efficacy, but they did both speak in general about the positive effects of taking the course. Nick recognized that once he started doing the work in the corequisite course, "the knowledge [from high school] came back to me really quickly" and he was able to feel more comfortable in the class. Shanelle claimed that the corequisite course made her enjoy math and she is now "more enthusiastic about math than [she] was when [she] started."

Cameron, Jasmine, Kaden, Nate, and Rebecca recognized the positive influence of the corequisite course on their math self-efficacy. Cameron became "more enthused to be like learning about math" and how the corequisite course "made [him] more confident to use [math] every day and not shy from it like [he] probably would have before." Jasmine acknowledged that the extra work in the corequisite course allowed her time to become more comfortable with the material being taught in the gateway course. Kaden described how "just taking that extra time really helps" because he procrastinates. Kaden liked the fact that he has "a structured class that will help [him]…it's been beneficial and really helpful in just like learning the material and practicing it and getting prepared for tests." When asked if the corequisite course affected the way he thinks about math, Nate stated,

> If anything, it's definitely made me more sure that I am confident in math. It has made me look at math with an even stronger point of me being able to do it than I had before…And it just helps me understand anything that I could possibly need help with.

Rebecca noticed that over the course of the semester she became more confident while taking tests because as her math content knowledge increased, she started to do better in the course,

> I finally felt like I had a backbone to rest on in case I didn't do as good as I thought I could because my scores were getting better…I felt like, 'Oh, I could actually just get a B on this and be fine' instead of 'Oh, I have to get like a 95.'

Rebecca found that her growing mathematics content knowledge helped her feel more confident and less stressed when taking tests. These students all benefitted from the extra time provided in the corequisite course structure for them to learn and master the material, which ultimately made them more confident in their own math ability.

Jackson started out struggling to understand the first few topics covered in the course, but he felt by the end of the course that he had a better grasp on the material. This led him to be less "anxious about the subjects." Ethan noted,

> I was pretty stressed at first because I just hadn't done math in a while. Then after doing it and seeing that I could do well in it, you know, you get that confidence back and yeah, are less anxious. So you're just less anxious overall because you know you've seen that you can do it.

Jackson and Ethan had the same instructor, although they were in different sessions of the corequisite course. This instructor always scheduled a day for test review where they would review things as a class. Both Jackson and Ethan credit this test review with easing their math anxiety and increasing their confidence going into a test. Overall, students felt that the amount of time they spent working on math, thanks to the additional hours spent in the corequisite course, helped decrease their math anxiety and increase their math self-efficacy.

Attendance and Participation Requirements. Only one student made a comment about the benefits of being held accountable through participation requirements in the corequisite course. Jasmine compared her experience in a math corequisite course to past corequisite courses that did not require any work. While she liked that she didn't "have the extra work to do" in her previous corequisite, she recognized that she was "paying to take this extra class, and [she was] not getting anything from it." She appreciated that the corequisite mathematics course held her accountable for "doing the problems and practicing" and she stated how this positively influenced her confidence in her own math ability.

Just-in-Time Learning. Out of the 11 students interviewed, six students discussed the influence of just-in-time learning on their experience in the corequisite course. Kaden and Shanelle both discussed how the corequisite course positively influenced their math self-efficacy. Kaden saw the positive effects on his confidence of just-in-time learning and described how the corequisite is "basically like its own class that follows the 143 class, which is, actually it's been very helpful." Kaden also thought that he would not be doing as well in his gateway course without the just-in-time learning he was receiving from the corequisite course. Shanelle also credited the corequisite class with helping increase her math self-efficacy, "knowing that there's like another class that could help me like do better in my classes and academics that's kind of boosted my confidence."

The other four students who mentioned the positive influence of just-in-time learning all noted how their math anxiety decreased and their math self-efficacy increased due to this feature of corequisite courses. Aaron thought "the support class was such a huge help" because he "can think back to like lessons that [he] definitely would not have gotten, if it wasn't for the support class. Like things like [he] 100% would have missed if it wasn't for the support class." He

thought that without the support class helping him make sense of the lessons from his gateway course that he would "be way less confident." Rebecca described how the corequisite course,

> Not only built my confidence to continue pushing in the college [gateway] course, but it also helped me like check myself. Like okay, we're learning this this week, do I remember this, am I still doing well with this, oh I'm not, then I need to go back and practice this. It was great.

She also described the course as being "that little extra boost [to her confidence] two times a week, like, oh this is so easy, I got this" and how she needed that just-in-time learning to feel more comfortable in her own math ability.

Jackson felt that "having a second class to like cover like similar topics really helped kind of like give [him] time to like figure things out," and he described how this helped decrease his math anxiety and helped slightly increase his math self-efficacy. Cameron noted how the corequisite course influenced his math anxiety and math self-efficacy, and how,

> It would just help me like refresh on things that I didn't understand, like I said, if one teacher, if my other [gateway] teacher taught it a certain way that was particularly difficult for me to understand…she [his corequisite instructor] would like break it down for me and simplify it for me. And yeah. I mean it helps to like know what you're going into before you go into it. So that's the kind of feel I got from that dynamic. They were back-to-back, so that helps also.

Cameron liked the back-to-back nature of corequisite and gateway courses and felt the positive effects of just-in-time learning. Overall, students claimed that the just-in-time learning aspect of corequisite courses helped decrease their math anxiety and increase their math self-efficacy during the semester.

Various Corequisite Course Modalities. Two of the students expressed excitement about being able to take their corequisite course in person. Shanelle, "was excited about like just being in person and learning in person because doing online is very stressful. I realized I cannot focus online, like at all, so just being in person very much excited me." Kaden was "thankful to be taking class in person cause online would be brutal." Kaden and Shanelle both signed up for in-person courses but started the spring 2022 semester synchronously online at Community College D due to high COVID rates. Kaden describes how he "didn't know what was happening" and how "that kind of just dropped [his] confidence…but when [they] started getting back in person and things started getting better that's when I started gaining more confidence in my abilities in this course."

Jose had to sign up for an asynchronous corequisite and gateway course due to logistical restrictions related to his job. He did not have a positive experience in the asynchronous corequisite course and felt like he "couldn't even understand what was going on until a month in." He also described how he "got super confused" and how he "was learning like a bunch of stuff, and it totally felt like [he] was drinking out of a fire hose." Jose thought that the asynchronous course format caused him anxiety. Ultimately, Jose noticed that his math anxiety stayed the same because he came into the course with high math anxiety and he left the course with high math anxiety, due to his experience taking a corequisite asynchronously.

Converging the Results

In this section, the quantitative and qualitative results of this study will be merged to understand the change in student's mindset, math anxiety, and math self-efficacy while taking a corequisite course. The pre-survey results will be compared to student comments about their feelings and beliefs at the start of the semester. Then, the gain scores for mindset, math anxiety,

and math self-efficacy will be compared to student comments about how their beliefs changed. Note that in the student interviews, a distinction was not made between general mindset and mathematical mindset. Thus, any comments made by students about their mindset were grouped while the survey results remain disaggregated by general and mathematical mindset.

How Students Felt at the Beginning of the Semester

How the interview participants felt at the beginning of the semester is described in Table 16. Students who did not make explicit comments about the influence of corequisite courses on

Table 16

Comparing Student Pre-Survey Scores to Interview Comments About How Students Felt at the Beginning of the Course

Student Name	Pre-Survey Responses				Interview Comments		
	General Mindset	Math Mindset	Math Anxiety	Math Self-Efficacy	Mindset	Math Anxiety	Math Self-Efficacy
Jose	3.67 Moderate	4 Growth	8 High	2.33 Low	Growth	High	N/A
Nate	5.33 Growth	5 Growth	2 Low	5.25 High	N/A	Low	High
Nick	5 Growth	6 Growth	1 Low	4.83 High	Growth	Low	High
Ethan	6 Growth	5.67 Growth	7 High	5 High	Growth	High	Low
Aaron	5.33 Growth	5 Growth	6 Moderate	3.83 Moderate	Growth	N/A	N/A
Jackson	5.67 Growth	6 Growth	7 High	2.5 Low	Growth	N/A	N/A
Cameron	5.33 Growth	4.33 Growth	10 High	4.17 High	Growth	N/A	N/A
Shanelle	6 Growth	6 Growth	5 Moderate	5.42 High	N/A	High	High
Kaden	3.67 Moderate	3.67 Moderate	9 High	2.83 Low	N/A	High	Low
Jasmine					N/A	High	N/A
Rebecca					Growth	High	N/A

their mindset, math anxiety, or math self-efficacy, were noted with an "N/A" in the table. Also, note that Jasmine and Rebeca did not take the pre-survey.

Mindset. Four interview participants were coded as not discussing their mindset. Two of these participants had growth mindsets and one had moderate mindset according to the pre-survey results. The fourth individual did not take the pre-survey, so there is no indication of their mindset at the start of the semester. Aaron, Cameron, Ethan, Jackson, Nick, and Rebecca all made comments representative of a growth mindset, which were also reflected in their pre-survey responses except for Rebecca who did not take the pre-survey. Jose also made comments representative of a growth mindset, but his general mindset score indicated a moderate mindset while his mathematical mindset score indicated a growth mindset.

Examples of comments made by students that were reflective of a growth mindset include Jose stating,

> I think my mindset now [in comparison to high school] in general is just like, I can learn anything, you know, as long as I make the time. And if I get enough practice in it, I'm going to be freaking awesome at it. So like as far as going into this class like I knew I was going to have to work hard, but I was willing to put in the work. So that's my mindset.

Aaron made a similar comment,

> I think having like that growth mindset makes you more open to, more open and less closed off to subjects…like when I see a math problem I don't understand, I know that I can understand it because I've seen math problems I didn't understand before and I get those now, you know. And I think like that initial, you know, looking at the wall and

> seeing that it's scalable goes a long way versus being like, oh, there's a wall, I can't move past this wall kind of thing.

Nick discussed how he "kind of tends to think that like if anyone really wants to put the time in to learn something that they can."

Math Anxiety. Of the students who were interviewed for this study, Nate and Nick described having low math anxiety at the start of the course, which was corroborated by their pre-survey results. Nick described how he felt "pretty positive" coming into the course and Nate stated how he did not "believe [he'd] ever had math anxiety." Shanelle described having high math anxiety at the start of the course, "I was extremely nervous. It seemed as though I was the only one who didn't understand statistics. And like everybody else was already good at the subject." Her pre-survey results indicated moderate math anxiety, which contrasted the statements made in her interview. Jackson, Cameron, Aaron did not make any explicit comments in the interview about their math anxiety prior to starting the course. Jackson and Cameron pre-survey results indicated that they had high math anxiety, while Aaron scored moderately.

Jasmine and Rebecca described having high math anxiety, but they only took the post-survey, so their interview responses were not able to be compared to their pre-survey results. Jasmine stated,

> So, I have just dyscalculia…Math is just not a thing I enjoy…The anxiety started in like third grade when I was doing all those timed multiplication sheets…So, embarrassment, anxiety, you know, all those things really like kind of punch me in the face every time I think about just doing math. So, I think that's where my hatred of math came from.

Rebecca stated how she is "just an anxious person when it comes to math." Jose, Ethan, and Kaden each had pre-survey results indicating they had high math anxiety, which was consistent

with the comments they made during the interview. Jose stated, “I don't think I've had that much anxiety for a class since high school.” Similarly, Ethan described being “pretty stressed at first just because it had been so long since [he’d] taken a math class.” When Kaden was asked how he feels about having to take a math course, he said how “it does bring on anxiety” and how his anxiety can be impacted when he would “get an answer, and then the teacher goes over and pulls up this completely different answer. That defeat feeling of like ‘oh my gosh what am I doing wrong. I literally thought I got all this.’”

Math Self-Efficacy. Six of the interview participants did not make comments about their math self-efficacy when they started the course. Of these six participants, survey results indicated that two had low self-efficacy, one had moderate self-efficacy, one had high self-efficacy, and two did not take the pre-survey. Kaden’s pre-survey results indicated a low self-efficacy and the comments he made in the interview confirmed this. He was concerned that since it had been about five years since he had taken a math class, he “did not know what [he] was gonna remember. [He] didn't know how this was going to turn out.” Ethan had a similar concern and was also categorized as making comments reflective of a low math self-efficacy. But unlike Kaden, Ethan’s pre-survey results did not match the comments he made, since he scored highly on the math self-efficacy scale.

Nate, Nick, and Shanelle all scored positively on the math self-efficacy scale and made comments reflective of this pre-survey score. Nate described how he’d always had high confidence in his own mathematical ability, “well I mean, once I got multiplication down, it was all kind of just, you know, I’m either multiplying, dividing, adding, I’m doing something like that. I just have to the remember basic principles.” Nick was slightly worried that there was going to be a gap in his knowledge that he would need to overcome, but that he was confident in

his ability to work hard to review anything he had forgotten. Shanelle described how she felt at the start of the course, “I was pretty confident, I would say. Like, I actually wanted to learn more about like statistics because I really don't know much of it.”

Overall, most students pre-survey results were consistent with how they described their mindset, math anxiety, and math self-efficacy at the start of the course in their interview. One student who thought they had a growth mindset at the start of the course had a moderate general mindset and a growth math mindset. One student described having high math anxiety when they began the course, but their pre-survey result was categorized as moderate math anxiety. Another student described having low math self-efficacy, but their survey result was representative of a high math self-efficacy.

How Students Felt at the End of the Semester

Next, how the interview participants felt their mindset, math anxiety, and math self-efficacy changed over the course of the semester is explored. If students did not make explicit comments, “N/A” was listed. In addition, comments made by participants about why and how their beliefs changed are described in the table with the associated code from the codebook.

Mindset. There was either no evidence of students discussing their change in mindset, or the students made comments implying that their mindset had not changed over the course of the semester. See Table 17 for an overview of students’ mindset at the end of the corequisite course. Of the six interviewees where there was no evidence, two students did not take the pre-survey, one student saw no change in their mindset scores from the pre- to post-survey, one student saw no change in their mathematical mindset but had a slight increase in their general mindset, and one student had a slight decrease in their general mindset and a slight increase in their mathematical mindset.

Table 17

Examining the Influence of Corequisite Courses on Students' Mindset

Student Name	Survey Data						Interview Data
	General Mindset			Math Mindset			
	Pre	Post	Change	Pre	Post	Change	
Jose	3.67 Moderate Growth	5 Growth	22.22%	4 Growth	5 Growth	16.67%	Didn't Change
Nate	5.33 Growth	5 Growth	-5.56%	5 Growth	5.33 Growth	5.56%	N/A
Nick	5 Growth	6 Growth	16.67%	6 Growth	6 Growth	0.00%	N/A
Ethan	6 Growth	5.67	-5.56%	5.67 Growth	5.33 Growth	-5.56%	Didn't Change
Aaron	5.33 Growth	5 Growth	-5.56%	5 Growth	5 Growth	0.00%	Didn't Change
Jackson	5.67 Growth	6 Growth	5.56%	6 Growth	6 Growth	0.00%	N/A
Cameron	5.33 Growth	4.33 Growth	-16.67%	4.33 Growth	4.33 Growth	0.00%	Didn't Change
Shanelle	6 Growth	6 Growth	0.00%	6 Growth	6 Growth	0.00%	N/A
Kaden	3.67 Moderate Growth		N/A	3.67 Moderate Growth		N/A	N/A
Jasmine		4 Growth	N/A		4.67 Growth	N/A	N/A
Rebecca		5 Growth	N/A		4.67 Growth	N/A	Didn't Change

Of the five interviewees where students claimed there was no change in their mindset, everyone described having a growth mindset when they started and ended the corequisite course. When comparing these five participants to their survey results, one could not be compared because they did not take the pre-survey. The other four participants saw slight increases and decreases in their general and mathematical mindset. Cameron described his mindset throughout the course,

> You can't not learn math or it's something that you can't just not do. So, it's like, you just have to do it. And I don't like not getting things or not understanding things, that's like

> frustrating. So, I'd rather just put myself through it and figure it out. So, like it's just myself motivating myself to like not feel dumb…I enjoy learning new things. So yeah, if I want to say I enjoy learning new things, I can't limit myself to like stop learning, if that makes sense.

Cameron believes that he is capable of learning and that if he works hard he can learn new things, which is reflective of a growth mindset. Other students made similar comments about their philosophy about learning, which were also classified as representing a growth mindset. Some students were in classrooms where study skills lessons that focused on mindset were incorporated, and two students in this study, Ethan and Jackson, remembered doing these study skills lessons but did not think they impacted their mindset. For Ethan, it was because "most of that stuff, especially about the growth mindset, [he'd] heard before, a lot, just from other classes and in high school." Jackson made a similar comment about this growth mindset lesson, "a lot of it kind of felt like stuff I already understood."

Math Anxiety. Students also discussed how the corequisite course influenced their math anxiety (see Table 18). Four students did not make any explicit comments about how their math anxiety changed over the course of the semester. Kaden and Jasmine did not complete both the pre and post-survey, so their gain score was not able to be calculated. Shanelle had high math anxiety at the end of the course, and Nick rated their math anxiety as the lowest possible score on both the pre and post-survey. Two other students, Jose and Nate, claimed that their math anxiety did not change over the course of the semester. Jose had consistently high math anxiety from the beginning to end of the course, and they claimed this was due to taking the corequisite and gateway course asynchronously. Nate made comments reflective of a low math anxiety from the start to end of the course, but their survey results showed a one-point decrease. Even though their

survey results showed a slight change, their pre-survey score was a two and their post-survey results were a one. Thus, both survey scores were reflective of a low math anxiety, which is consistent with their interview responses.

Table 18

Examining the Influence of Corequisite Courses on Students' Math Anxiety

Student Name	Survey Data			Interview Data
	Pre	Post	Change	
Jose	8 High	8 High	0.00%	Didn't Change Course Modalities
Nate	2 Low	1 Low	-10.00%	Didn't Change
Nick	1 Low	1 Low	0.00%	N/A
Ethan	7 High	3 Low	-40.00%	Decreased Time Spent in Course
Aaron	6 Moderate	4 Low	-20.00%	Decreased Just-in-Time Learning
Jackson	7 High	4 Low	-30.00%	Decreased Just-in-Time Learning Time Spent in Course
Cameron	10 High	6 Moderate	-40.00%	Decreased Just-in-Time Learning
Shanelle	5 Moderate	7 High	20.00%	N/A
Kaden	9 High		N/A	N/A
Jasmine		10 High	N/A	N/A
Rebecca		10 High	N/A	Decreased Just-in-Time Learning

Five students were classified as having a decreased math anxiety over the course of the semester. One of these students claimed this was due to the extra time spent in the course, three of these students attributed this decrease to opportunities for just-in-time learning, and one student made comments about how the time spent in the course and the just-in-time learning both contributed to his decreased math anxiety.

Math Self-Efficacy. Students also discussed how the corequisite course influenced their math self-efficacy (see Table 19). Two students did not make explicit comments about how their math self-efficacy changed while taking the corequisite course. One of these students, Jose, saw an increase in their math self-efficacy over the course of the semester, while the other student, Nick, saw a slight decrease in their math self-efficacy.

Table 19

Examining the Influence of Corequisite Courses on Students' Math Self-Efficacy

Student Name	Survey Data			Interview Data
	Pre	Post	Change	
Jose	2.33 Low	3.08 Moderate	12.50%	N/A
Nate	5.25 High	5.83 High	9.72%	Increased Time Spent in Course
Nick	4.83 High	4.67 High	-2.78%	N/A
Ethan	5 High	4.83 High	-2.78%	Increased Time Spent in Course
Aaron	3.83 Moderate	4.5 High	11.11%	Increased Just-in-Time Learning
Jackson	2.5 Low	2.67 Low	2.78%	Increased Just-in-Time Learning Time Spent in Course
Cameron	4.17 High	4.25 High	1.39%	Increased Just-in-Time Learning Time Spent in Course
Shanelle	5.42 High	5.42 High	0.00%	Increased Just-in-Time Learning
Kaden	2.83 Low		N/A	Increased Just-in-Time Learning Time Spent in Course
Jasmine		3.58 Moderate	N/A	Increased Time Spent in Course Participation Requirements
Rebecca		4.08 High	N/A	Increased Just-in-Time Learning Time Spent in Course

The other nine students all claimed that their math self-efficacy increased over the course of the semester. Nate and Ethan credited the time spent in the course with the increase, while Aaron and Shanelle credited the just-in-time learning with their increase in self-efficacy. Although Ethan and Shanelle implied their self-efficacy increased, Ethan's survey results indicated a slight decrease in his math self-efficacy and Shanelle's survey results indicated that there was no change. Cameron, Jackson, Kaden, and Rebecca acknowledged that their increase in self-efficacy was due to the time spent in the course and the just-in-time learning available in the corequisite course. Finally, Jasmine, acknowledged that her change in belief was due to the time spent in the course and the participation requirements. Jasmine, Kaden, and Rebecca did not take both the pre- and post-survey, thus did not have a gain score their comments could be compared to. Cameron and Jackson both claimed that their math self- efficacy increased, and their survey results indicated they had small increases in their math self-efficacy.

Overall, the students who completed an interview either had a growth mindset or a moderate mindset at the start of the course, and every interview participant had a growth mindset at the end of the course. The only comments students made about their mindset in the interviews was that their mindset did not change over the course of the semester nor was it influenced by the structure of the corequisite course. In terms of students' math anxiety, the students who took both the pre- and post-survey and completed an interview had less math anxiety at the end of the course. All but one student was categorized as having either moderate or high math self-efficacy at the end of the semester. Students recognized the influence of the time they spent in the corequisite working on problems and the opportunity for just-in-time learning as the two main reasons for why their math anxiety decreased and their math self-efficacy increased while taking

a corequisite course. In addition, one student noted that the participation requirements positively impacted their math self-efficacy.

Discussion

Atkins and Beggs (2017) found positive outcomes for students taking corequisite courses in terms of their mathematics proficiency and efficiency of earning their mathematics credit. They theorized that the frequent, sometimes daily, access to mathematics faculty allowed for fewer opportunities for unexpected challenges that could negatively impact student's success in corequisite courses and that students benefitted from this course structure. Findings from this study, corroborate the theory proposed by Atkins and Beggs (2017). In the interviews, students discussed the extra time provided by the corequisite course and commented on how this time benefitted them by allowing them extra time to practice. In addition, the corequisite course model provided them with dedicated time that they could devote to their mathematics learning that they might not have put in otherwise. In addition, Campbell (2015) found that students who were anxious about taking math at the beginning of the semester gained confidence in their mathematics ability and began to enjoy math by the end of the semester. Findings from the interviews showed a similar interaction between mathematics anxiety and confidence, as interviewees claimed that the time spent in the corequisite course helped increase their own confidence in their mathematics ability which also helped decrease their mathematics anxiety.

A common argument for why corequisite courses are so advantageous to students is the opportunity for just-in-time learning, which allows students to complete their developmental and college-level mathematics coursework simultaneously without making students feel like they were taking a course that was setting them back (Kashyap & Mathew, 2017; Logue et al., 2016). Just-in-time learning refers to the necessary developmental curriculum being offered in the

corequisite course that aligns to the content being discussed in the gateway mathematics course. This characteristic of corequisite courses aids students in building the foundation they need to understand a topic in their gateway mathematics course (Mireles et al., 2014; Mullins, 2018). Kim (2016) found that student's math self-efficacy significantly increased due to just-in-time support in corequisite courses, which is similarly noted in this study. Several interview participants discussed how the just-in-time learning in corequisite courses helped increase their math self-efficacy during the semester. In addition, students also discussed how their math anxiety decreased due to this characteristic of corequisite courses. In addition, evidence exists that supports attendance and participation policies for students in corequisite courses (Atkins & McCoy, 2016; Campbell & Cintron, 2018). The participation requirements of corequisite courses was cited by one interviewee as a reasons that their math self-efficacy increased from the beginning to end of the semester.

On average students in this study possessed a growth mindset over the course of the semester and students did not credit any characteristic of corequisite courses as impacting their mindset. In fact, several of the students who were interviewed indicated that growth mindset was something they were familiar with and was discussed by their past teachers. Research in the past ten years about how to incorporate a growth mindset school culture or how to encourage growth mindset-oriented thinking in classrooms has become more prevalent (e.g., Jaffe, 2020; Ricci, 2021; Yettick et al., 2016), which could be why several of the students in this study were familiar with growth mindset. This exposure to growth mindset could explain why there were not significant increases in student's mindset over the course of the semester. The negative shift in student's general mindset that was seen in this study is something that would need to be further explored to better understand.

Three students who were interviewed had high math anxiety at the end of the course according to their post-survey responses. One of these students, Jose, felt that their experience taking an asynchronous corequisite impacted his high math anxiety over the duration of the course. The other two interview participants, Jasmine and Rebecca, only took the post-survey, so their change in math anxiety was not able to be calculated, but they both claimed to have high math anxiety when they began the course. Both of these students cited past negative experiences that caused their high math anxiety and described how this had been an ongoing feeling for them throughout their lives. For example, Jasmine believes her math anxiety started when she had to take timed multiplication tests in elementary school. Research shows that math anxiety can start in children as young as elementary school (Maloney & Beilock, 2012) and can persist in community college students (Zientek et al., 2010). Thus, with math anxiety possibly spanning back to early elementary for some of the students placed into corequisite mathematics courses, it can be difficult to overcome their math anxiety in one course. The students taking corequisite courses in this study had lower math anxiety at the end of the semester, although it was not a significant difference. This supports the theory that even though corequisites help lessen students' math anxiety, it may be impossible to overcome students' math anxiety in one course.

Limitations and Future Research

Even though there was a large target population for the survey administration, there was a small number of students who took both the pre- and post-survey. Some reasons this could have occurred were: (a) a lack of buy-in from the instructors across the four different community colleges, so not all instructors administered the survey to their corequisite students; (b) the end of the semester got busy for instructors, so they did not have a chance to administer the post-survey; (c) instructors only administered either the pre- or post-survey, but not both; or (d) students could

have been absent on either the day of the pre- or post-survey. In addition, the context of this study offers a unique perspective of the impact of corequisite courses which may not be generalizable to smaller, rural community colleges or outside of North Carolina.

Instructors were asked to administer the survey during the first two weeks of the course, but by this time students' beliefs could have already been impacted. Ideally in a future study, a survey would be administered on the first day of class. Another limitation of the survey data was the lack of demographic data about participants. This was due to the fact that when seeking IRB approval, one of the colleges participating in this study did not want student demographic data to be collected. Future studies could purposefully select participants based off their survey results and demographic data to help ensure that the full scope of the influence of corequisite courses on student beliefs across various backgrounds was being explored.

The interviews were semi-structured and did not include questions that explicitly asked students about their mindset, math anxiety, or math self-efficacy at the beginning of the semester. In addition, during the interviews it was sometimes unclear if students were talking about their math anxiety or their anxiety in a more general sense. Thus, future research could more deeply explore student beliefs when they began the course and could also work to tease out their math anxiety. This study specifically looked at the impact of the corequisite course on student's mindset, math anxiety, and math self-efficacy. Future research should explore the influence of corequisite instructors on students to more cohesively understand why and how students' beliefs changed over the course of the semester.

Conclusion

A parallel mixed methods design was used to investigate if students' mindset, math anxiety, and math self-efficacy are impacted during a semester-long corequisite mathematics

course. Students' math self-efficacy significantly increased, and their math anxiety decreased over the course of the semester. In addition, students with a higher math self-efficacy at the end of the semester were more likely to be satisfied with their final grade. Students' mathematical mindset did not significantly change, but student's general mindset significantly decreased towards a fixed mindset. Students described how the time spent in the corequisite course, the opportunity for just-in-time learning, and the participation requirements of corequisite courses helped decrease their math anxiety and increase their math self-efficacy while taking a corequisite course.

CHAPTER 4: A Mixed Methods Approach Investigating the Impact of Community College Instructors on Students' Mathematics Beliefs in Corequisite Mathematics Courses

Introduction

Approximately 50% of students complete and pass all their required developmental coursework (Chen & Simone, 2016), and of these students, the percentage who complete their college-level mathematics course has been estimated to be even less (Bailey et al., 2010; Ganga et al., 2018; Jimenez et al., 2016). Researchers, policymakers, and college and university staff have implemented and researched developmental mathematics course redesigns in an effort to increase the pass rates of students required to take developmental mathematics (e.g. Kosiewicz, 2016; Ganga et al., 2018). The institutional reforms and course redesign efforts have shown promise, but research is still needed to fully understand and address the challenges facing developmental mathematics students. Many college students face multiple, daunting obstacles towards graduation, but earning their mathematics credit should not be one of them.

At community colleges in North Carolina, the corequisite course model has recently been implemented in place of a traditional developmental mathematics sequence. Corequisite courses at these community colleges meet a student's developmental math credit and are taken concurrently with a student's college-level mathematics course, also referred to as a gateway mathematics course. This study will explore the influence of corequisite mathematics instructors on students' mindset, math anxiety, and math self-efficacy. In the following section, I will describe the format of corequisite courses and common instructional practices students are likely to experiences in corequisite courses. Then, I will define and discuss the relevant literature regarding mindset, math anxiety, and mathematics self-efficacy.

Literature Review

In the co-requisite course model, students take a college-level mathematics course with a supplemental, developmental-level course where they receive just-in-time assistance to support their learning (Atkins & McCoy, 2016). This allows students in the corequisite course to seek help on topics covered in their college-level course that they do not remember or find themselves struggling to understand. Correct and consistent pacing of both the college-level and co-requisite courses ensures students are learning material as needed, providing students with just-in-time assistance that helps them succeed in their college-level, credit-bearing math course.

Most of the encouraged teaching methods utilized in these redesigned courses are in stark contrast to the traditional lecture-based delivery method students are used to seeing. Researchers suggest that to effectively reach students and to increase completion rates, alternate teaching methods are needed (Smith et al., 2015; Smith et al., 2017). A common justification for the use of alternate teaching practices is the repetitive nature of the content taught with respect to students' K-12 mathematics education. Findings show that corequisite course instructors commonly employed practices to create learner-centered environments through group work, discussion, etc. (e.g., Finder-Atkins & Stockdale, 2017; Logue et al. 2016). In an experimental study, developmental math students who received reform-oriented teaching did significantly better on several achievement tests than their peers who received lecture-based instruction (Smith et al., 2015). The reform-oriented instruction asked the instructor to primarily serve as a facilitator while encouraging a collaborative learning environment for their students while they worked on real-world problems. Not only should developmental education departments and colleges redesign the course structures, but they should work to improve student learning through alternate teaching practices.

It is recommended that professional development for faculty is designed and completed about instructional best practices in the corequisite course (Redl, 2020) and the components of self-efficacy that contribute to students' personal empowerment (Campbell, 2015) when a corequisite course model is implemented at an institution. Students who enroll in developmental mathematics have often been considered vulnerable and in need of a variety of instructional practices (Bonham & Boylan, 2011; Osterholt & Barratt, 2012). Instructors should not only address student gaps in content knowledge via collaborative learning environments, but should also help students develop study skills, time management, and their math self-efficacy (Osterholt & Barratt, 2012).

Mindset

Fixed and growth mindset will be defined using Dweck's (2006) definitions. A fixed mindset exists in an individual when they believe they have a limited amount of intelligence. These individuals have a fear of failure because they think setbacks indicate incompetence and that a smart individual should always succeed easily and without extensive effort. Specifically, they believe that if they are required to put effort into completing a task, then they are not competent in that area. An individual with a growth mindset believes their knowledge can be nurtured through their effort and experiences and that they have to work for their successes in life. Individuals with a growth mindset make learning a priority, and they embrace their mistakes so they can learn from them in order to increase their intelligence.

Making mistakes in a mathematics classroom is an important part of the learning process (Boaler, 2016; Dweck, 2006). In fact, brain activity was greater following a mistake for individuals with a growth mindset compared to those with a fixed mindset (Moser et al., 2011). Individuals often react negatively when they make a mistake, but in fact, mistakes should be

celebrated by teachers in the classroom because mistakes are an opportunity for learning (Boaler, 2016). Even though research has shown the positive benefits of mistakes, students still struggle to embrace their mistakes as a part of the learning process in the mathematics classroom and some were even unwilling to embrace challenging mathematical tasks when prompted by their teachers (Fraser, 2018). Creating a learning environment in the classroom that embraces mistakes and growth mindset attitudes can provide students with a space to share their learning process and any difficulties they encountered (Fraser, 2018; Rhew et al., 2018). A growth mindset-oriented classroom can require permanent culture changes for a teacher and their students.

A growth mindset intervention was implemented in a college developmental mathematics class (Mills & Mills, 2018). Results showed that participants receiving the mindset intervention had significantly higher final course grades than those in the control condition and that participants with high mindset scores earned significantly higher final grades than those with low scores. In addition, a year-long statistics course incorporated growth mindset affirmations into the start of every class (Samuel & Warner, 2021). Students believed that the instructors' role in facilitating the intervention was important, that the affirmations allowed them to start each class with a fresh start, and that the affirmations gave students a boost of confidence throughout each class session and the entire semester. In addition, students thought that saying the growth mindset affirmations daily helped them to believe these statements and impacted their beliefs about their mathematics ability and their mindset. Instructors play an important role in creating a classroom culture that embraces growth mindset attitudes.

Math Anxiety

An individual experiences mathematics anxiety when they have feelings of tension, apprehension, or fear that interferes with their mathematics performance (Ashcraft, 2002).

Community college students, especially developmental mathematics students, experience mathematics anxiety, and instructors should be educated on the impact math anxiety can have on student achievement (Zientek et al., 2010). In addition, instructors should also be aware of ways to help decrease students' math anxiety, so that students are better prepared to succeed in their college mathematics course.

Social influences and cognitive predispositions can play a role in the development of math anxiety in elementary students (Maloney & Beilock, 2012). One of the most prominent social influences in the classroom is the teacher. Beilock et al. (2010) found that by the end of a school year, if a female elementary math teacher's math anxiety was high, then their female students had lower math achievement and were more likely to confirm the stereotype that they were not as good at math as boys. Students who already feel they are behind in their mathematical understanding may be especially predisposed to pick up on social cues from their teacher that could highlight math in a negative view (Maloney & Beilock, 2012).

In a study that investigated the relationship between developmental mathematics students' mathematics anxiety and their academic performance, students recommended that math teachers could reduce their mathematics anxiety by being available outside of class and teaching well-paced lessons (Raju, 2018). Nicoloff (2018) recommends that developmental mathematics instructors identify students with high anxiety and negative attitudes towards mathematics and support those students in the increasing their confidence in mathematics. One method to decrease students' mathematics anxiety is to help students develop basic study skills by helping students learn how to study for exams, complete homework efficiently and sufficiently, and ask questions in class (Kee & Brooks, 2018; Nicoloff, 2018). Incorporating basic skills as part of the curriculum can help teach students how to be a good student, and ultimately help them succeed

in the course (Kee & Brooks, 2018). Some of the community colleges selected for this study have incorporated lessons surrounding these and additional skills into the curriculum for their corequisite courses. Thus, this study fills a gap in the literature by investigating if the incorporation of this content into the curriculum of the course by the instructor can impact a students' math anxiety over the course of the semester.

Math Self-Efficacy

Self-efficacy can be defined as an individual's belief in their ability to execute a task (Bandura, 1977). A student's confidence in their mathematical ability can impact their achievement and engagement in a course. Students in a corequisite Statistics course showed significant increases in their interest, growth, and utility domains, and the authors believed this increase could be because students were more likely to form self-initiated study groups and were more likely to attend their accompanying workshop (Logue et al., 2016). Similarly, Kim (2016) found there were significant differences in the change in mathematics self-efficacy over the course of a semester in corequisite students but not for students in a traditional sequence. In addition, attendance rates for corequisite students were significantly higher, and they claimed to be more satisfied by the course (Kim, 2016). Overall, corequisite students expressed a higher level of enthusiasm toward the learning process and were more actively engaged in the classroom compared to their peers in a traditional developmental math sequence (Kashyap & Mathew, 2017; Kim, 2016).

The corequisite course model is learner-centered and accounts for the academic and nonacademic factors students face while in school. The academic and personal support students receive in the corequisite model can lead to positive perceptions of their mathematics abilities (Hennessey et al., 2021). Furthermore, instructors noticed students in the corequisite course

model appeared to benefit from the daily interaction with instructors, their peers, and the content (Atkins & Beggs, 2017). Instructors also noticed increased levels of student engagement in the classroom and a greater sense of community among students (Redl, 2020). A common theme from interviews with corequisite students was that the design and structure of the corequisite course model was influential to students' success (Campbell, 2015; Kim, 2016). Students enjoyed that material was presented in quick succession and that they received frequent summative and formative feedback about their progress from their instructors (Campbell, 2015).

There was a close relationship between student mathematics self-efficacy and achievement in corequisite course models, and students believed their self-efficacy increased due to the various pedagogical strategies used by instructors (Campbell, 2015; Kim, 2016). These pedagogical strategies include: a) required attendance; b) group work; c) one-on-one instruction; d) use of web-based learning tools; and e) the creation of a collaborative learning environment. Students liked working in groups because they felt it helped increase their understanding, promoted friendly competition, and encouraged them to be an active learner (Campbell, 2015; Kim, 2016). Students who initially faced anxiety about doing math stated that by the end of the course they enjoyed math (Campbell, 2015). Some students cited the one-on-one instruction they received as the cause of their increase in confidence and reduction of anxiety (Kim, 2016). Participants gained confidence about their learning and benefitted from the corequisite course design. On the other hand, students who were placed into the traditional developmental mathematics sequence felt like the prerequisite was a setback and were disappointed by their placement in this course (Kashyap & Mathew, 2017). These students did not exhibit confidence or motivation, were more likely to be disengaged in class, and were not interested in the material since they had been exposed to the same content in high school. Whereas the students in the

corequisite model appreciated the content in the corequisite course because they were simultaneously applying this knowledge in their gateway course.

Researchers have shown promising findings about corequisite students passing their developmental and gateway mathematics courses (e.g., Childers et al., 2021; Logue et al., 2016) and students outperforming their peers in a traditional developmental course sequence on their final exams and their final course grades (Kashyap & Mathew, 2017). Although, much of the research involving corequisite mathematics courses has been student achievement focused. There is a lack of research that analyzes the impact of instructor's teaching strategies on student's mindset, math anxiety, and math self-efficacy in a corequisite mathematics classroom. This study will address these gaps in the literature by investigating instructor impact on student's beliefs during a semester-long corequisite mathematics course.

Methodology

To determine the influence of corequisite mathematics course instructors on community college students' mindset, math anxiety, and math self-efficacy, a convergent mixed methods research design was utilized (Creswell & Plano Clark, 2018). A student pre- and post-course survey and an instructor survey were used to measure students' and instructors' mindset, math anxiety, and math self-efficacy. Semi-structured interviews with students and instructors investigated the influence of corequisite instructors on students, specifically their beliefs, and how instructors addressed students who had negative beliefs. When reporting on this convergent mixed methods design, survey and interview data was summarized separately and then merged to create greater insight into the influence of instructors on their students' mindset, math anxiety, and math self-efficacy. In the next sections, I will state the research questions, and then describe the study participants, the data collection process, the data analysis, and my positionality.

Research Questions

This study will be guided by the following research question:

3. How do corequisite mathematics instructors impact their students' mindset, math anxiety, and math self-efficacy?
    a. To what extent does the change in students' mindset, math anxiety, and math self-efficacy vary between instructors?
    b. In what ways does the instructor influence students' mindset, math anxiety, and math self-efficacy?

Participants

Mathematics departments and administrators at nine North Carolina community colleges were contacted via email and asked if they would be willing to participate in my study. Approval was granted from four of the Dean and/or Department Heads that oversaw developmental education courses at these community colleges, which will be referred to as Community College A, B, C, and D. These community colleges were recruited for this study because they had each recently adopted corequisite mathematics courses, in the spring of 2019 at community college B, in the fall of 2019 for community colleges A and D, and in the fall of 2020 at community college C. These community colleges are comparable based on their locations in a major city and are representative of some of the largest community colleges across the state. In addition, all North Carolina community colleges utilize the same course objectives for the five course pathways, Math Measurement and Literacy, Algebra/Trigonometry I, Quantitative Literacy, Statistical Methods I, and Precalculus Algebra. Data were collected in the fall of 2022 at all four community colleges and in the spring of 2022 at community college D.

Every instructor teaching corequisite courses at the four colleges were contacted via email and asked to participate in the study. Their participation involved: (a) sharing the pre- and post-survey with their students; (b) completing an instructor survey; and/or (c) completing an interview. Participating instructors asked all of their students to complete a pre- and post-survey. If students or instructors completed the survey, they were asked a question about whether they would be willing to complete an interview. In the spring of 2022, six students volunteered in their survey response to be interviewed, and three completed an interview. In the fall of 2022, 56 students volunteered in their survey response to be interviewed, fourteen students scheduled interviews, but only eight students completed an interview. I had intended to purposefully select interview participants based off their survey responses if I received more than 15 responses, but this was unnecessary. In addition, I was going to purposefully select instructor interview volunteers if more than five from a college offered to complete an interview. The number of instructor interview volunteers never exceeded five at a college, thus, I interviewed every instructor who volunteered.

The number of participants who completed the survey and/or interview is detailed in Table 20. The community college attended by the student interview participants, as well as the course pathway and modality they took is detailed in Table 21. Similarly, an overview of where instructors taught and what courses pathways and modalities they have taught is detailed in Table 22 for the instructor interview participants.

Data Collection

In this section I will describe the instructor and student pre- and post-survey data collection procedures and the constructs being measured in the survey. Then, I will describe the interview procedure and the instructor and student interview protocols.

Table 20

Number of Instructor and Student Survey and Interview Participants

	Community College A	Community College B	Community College C	Community College D		Total
	Fall 2022	Fall 2022	Fall 2022	Spring 2022	Fall 2022	
Student Pre-Survey	34	49	12	32	47	174
Student Post-Survey	13	27	16	17	22	95
Student Complete Survey Data	8	13	4	5	17	47
Student Interview	2	2	0	3	4	11
Instructor Survey	3	5	2	0	5	15
Instructor Interview	4	5	2	0	2	13

Table 21

Overview of Student Interview Participants

College	Participant Pseudonym(s)	Course Modality	Course Pathway
A	Jasmine, Jose	Asynchronous	Quantitative Literacy
B	Cameron	In-person	Quantitative Literacy
	Nate	In-person	Algebra/Trigonometry I
D	Nick	Asynchronous	Precalculus Algebra
	Aaron, Ethan, Jackson, Rebecca	In-person	Precalculus Algebra
	Kaden	In-person	Quantitative Literacy
	Shanelle	In-person	Statistical Methods I

Instructor and Student Survey Data Procedure

At the beginning and end of the semester, corequisite mathematics instructors were asked to facilitate a pre- and post-survey to their students. Instructors were asked to complete the survey at the same time they administered the student post-survey. Both the instructor and student pre- and post-surveys were administered through Qualtrics. An email sent at the beginning and end of the semester asked instructors to administer the survey to their students, explained the purpose of the study, asked them to read a brief overview of the study to their

Table 22

Overview of Instructor Interview Participants

College	Participant Pseudonym	Course Modalities	Course Pathways
A	Amy	In-person	Quantitative Literacy; Precalculus Algebra
	Bianca	Asynchronous In-person	Math Measurement & Literacy; Quantitative Literacy; Precalculus Algebra
	Mikayla	Asynchronous In-person	Math Measurement & Literacy; Algebra/Trigonometry I; Quantitative Literacy; Precalculus Algebra
	Trinity	Asynchronous In-person	Quantitative Literacy
B	Caroline	Asynchronous In-person Synchronous	Math Measurement & Literacy; Quantitative Literacy; Statistical Methods I; Precalculus Algebra
	Lizbeth	Asynchronous	Precalculus Algebra
	Paige	Asynchronous In-person	Math Measurement & Literacy
	Ruby	Asynchronous In-person	Quantitative Literacy; Statistical Methods I
	Valeria	Asynchronous In-person Synchronous	Quantitative Literacy
C	Diana	Asynchronous	Quantitative Literacy; Precalculus Algebra
	Kyle	Hybrid	Algebra/Trigonometry I
D	Samantha	Asynchronous In-person	Quantitative Literacy; Statistical Methods I; Precalculus Algebra
	Sophia	Asynchronous In-person	Math Measurement & Literacy; Algebra/Trigonometry I; Quantitative Literacy

students, and provided the survey links. Follow-up emails were sent to remind instructors to share the survey with their students and to take the instructor survey. Only students 18 years old and older could complete the survey. See Appendix E for the student pre-survey, Appendix F for the student post-survey, and Appendix I for the instructor survey.

A Description of the Instructor and Student Survey

Students and instructors took similar surveys. The survey asked for the course(s) they took or have taught, the section number of the course(s), and the modality of the course(s) they took or have taught. The survey also asked questions that measured a participant's mindset, math anxiety, and math self-efficacy. How each of these beliefs was measured is described below.

Mindset. Dweck et al. (1995) created a three-item, six-point Likert scale measure to gauge a respondents' mindset. The three items are: (a) "You have a certain amount of intelligence and you really can't do much to change it"; (b) "Your intelligence is something about you that you can't change very much"; and (c) "You can learn new things, but you can't really change your basic intelligence" (Dweck et al., 1995, p. 269). The surveys include two versions of this measure, a version that measures a participants' general intelligence mindset and one that measures their mathematical mindset. The version that measures instructors' and students' mathematical mindset asked the same three items stated above with the addition of "math" in front of intelligence.

The score of the three mindset items were averaged to form an overall general and math mindset score, with higher scores indicating a stronger growth mindset. Participants with scores less than or equal to three are considered to have a fixed mindset and those who score a four or more were classified as having a growth mindset (Dweck et al., 1995). This three-item mindset measure created by Dweck and colleagues (1995) is a reliable and valid measure of mindset. This measure has a strong test-retest reliability over a two-week period, 0.80, and has a high internal reliability, ranging from 0.94 to 0.98. In addition, this measure is independent of a respondents' age, sex, cognitive ability, confidence in intellectual ability, self-esteem, and optimism.

Math Anxiety. Participants' math anxiety was measured by the Single-Item Math Anxiety Scale (SIMA) developed by Ashcraft (2002) that asks, "On a scale from 1 to 10, how math anxious are you?" A response of one indicates a participant was not math anxious and ten indicates a participant was very math anxious. Math anxiety scores that are less than or equal to four were categorized as low math anxiety, while scores of seven or greater were categorized as high math anxiety. The math anxiety scores were categorized this way in an effort to minimize the number of students who are categorized as having moderate math anxiety.

This measure has been shown to be a valid and reliable measure of assessing participants' math anxiety (Nunez-Pena et al., 2014). Specifically, Nunez-Pena et al. (2014) found that responses to this single-item measure correlated with the Shortened Mathematics Anxiety Rating Scale (sMARS; Alexander & Martray, 1989) with a strong positive correlation between the scores, $r = 0.77$ and that the test-retest reliability for SIMA over a seven-week period was 0.81. In addition, this scale was selected because I did not want to ask participants to complete an unnecessarily long survey, such as the 98-item Math Anxiety Rating Scale (MARS; Richardson & Suinn, 1972), that could result in students not completing or not finishing the survey.

Math Self-Efficacy. The Confidence in Learning Mathematics Scale (CLMS) is one of the nine Fennema-Sherman Mathematics Attitudes Scales (1976) and measures a participants' confidence in their ability to learn and perform well on mathematical tasks. This scale consists of twelve, six-point Likert scale items that measure a participants' mathematics self-efficacy. The scale consists of six items which reflect a positive affective view (i.e., "I am sure I could do advanced work in mathematics.") and six items which reflect a negative affective view (i.e., "I'm no good at math."). Half of the items were reverse coded and then all of the items were averaged to create an overall score for a participants' mathematics self-efficacy. The CLMS and mindset

measures are both six-point scales, so the same classification scale that was used on the mindset measure was used to categorize student math self-efficacy scores. Therefore, participants with scores less than or equal to three are considered to have low math self-efficacy, while those with scores greater than or equal to four are considered to have high math self-efficacy.

The Fennema-Sherman Mathematics Attitudes Scales were administered to 1,541 junior high school students and evidence was found to support the scales, specifically that each of the nine Fennema-Sherman scales measured a different construct and that together the scales describe a participants' mathematical attitude (Broadbooks et al., 1981). In addition, factor analyses of the scales were performed (Broadbooks et al., 1981), and the results were comparable to those originally reported by Fenneman and Sherman (1976). Wikoff and Buchalter (1986) showed the CLMS has a high internal reliability, 0.95, and found that the scale can be generalized to college populations. Overall, the CLMS is a reliable measure of a students' mathematics self-efficacy.

Instructor and Student Interviews

Instructors and students were interviewed about the influence of instructors on students who are taking a corequisite course. Interviews were semi-structured to allow for follow-up questions. Interviews were conducted and audio recorded via Zoom, lasted between thirty minutes to an hour, and participants were compensated for their time with a $15 Amazon gift card. Interview questions asked instructors about their teaching style and philosophy, their perceptions of their student's beliefs, what they do when their students make mistakes in the classroom, and how their experiences as a student impacted their teaching. Interview questions asked students about their experiences in corequisite courses, their instructors teaching, and how their instructor could have influenced their mindset, math anxiety, or math self-efficacy over the

course of the semester. Interviews were transcribed by the researcher. See Appendix J for the student interview protocol and Appendix K for the instructor interview protocol.

Data Analysis

In order to answer the research questions, the survey and interview data were analyzed separately, but then the results were merged to determine the impact of instructors on their students' mindset, math anxiety, and math self-efficacy in a corequisite mathematics course.

Instructor and Student Surveys

The survey results were used to calculate a score for general mindset, math mindset, math anxiety, and math self-efficacy. In addition, a post-survey minus pre-survey gain score was calculated for each construct to represent the change in students' general and math mindset, math anxiety, and math self-efficacy from the beginning to end of their corequisite course. Descriptive statistics for the general and math mindset, SIMA, and CLMS scores were calculated for students and instructors. Then, an ANOVA analysis was conducted to determine if there are significant differences in the change in students' general and math mindset, math anxiety, and math self-efficacy, given their instructor.

Instructor and Student Interviews

To understand how instructors influence their student's mindset, math anxiety, and math self-efficacy, aspects of their personality and teaching that affect their student's beliefs formed the basis for the codebook. Based on the literature, the initial codebook included seven codes: (a) how instructors reacted to and approached mistakes (Boaler, 2016; Moser et al., 2011); (b) how instructors made things relatable and used real-world examples (Kashyap & Mathew, 2017); (c) how instructors created a classroom culture where students felt safe and comfortable (Fraser, 2018; Rhew et al., 2018; Samuel & Warner, 2021); (d) the impact of one-on-one instruction

(Kim, 2016); (e) how instructors helped their students develop study skills (Kee & Brooks, 2018; Nicoloff, 2018); (f) instructors availability to help students outside of class (Raju, 2018); and (g) if instructors allowed students to work together in a collaborative environment (Campbell, 2015; Kim, 2016; Raju, 2018; Smith et al., 2015). In addition, inductive in vivo coding (Saldaña, 2013) was used to capture additional aspects of corequisite instructor's personality or teaching style that impacted students. These additional codes included a lack of interaction between students and instructors, a lack of time for instructors to address students' negative beliefs, descriptions of instructors' teaching philosophy, things instructors did not do in their classroom, how instructors work through problems, and an instructor's personality or disposition. See Appendix L for the finalized codebook.

The student and instructor interviews were coded separately but were coded using the same codebook. After the coding was completed, the codes were combined into four broader themes (Saldaña, 2013), pedagogical decisions, instructor disposition, student and instructor interactions, and classroom environment. In addition, a second researcher coded 20% of the interview transcripts, which helped establish reliability and trustworthiness of the codebook. An initial agreement of 83.84% was reached by the two coders. During this process, the codebook and the descriptions of the codes were refined, and the coding of the transcripts was finalized.

Converging the Results

In a parallel convergent mixed methods design, the quantitative and qualitative data is collected and analyzed separately, before being merged and analyzed collectively (Creswell & Plano Clark, 2018). The combination of instructor and student interviews, instructor survey data, and student pre- and post-survey data, as well as researcher memos written throughout the data collection and analysis process helped ensure trustworthiness of the results. To determine how

instructors influence students' mindset, math anxiety, and math self-efficacy, the results from the student surveys and the student interview data were merged. The quantitative results highlight the differences in students' mindset, math anxiety, and math self-efficacy gain scores among instructors. While the qualitative results explore how students' change in mindset, math anxiety, and math self-efficacy is influenced by their instructor, specifically, how students and instructors interact, their instructor's disposition, their instructor's pedagogical decisions, and the environment created by their corequisite instructor. When these data were merged, the commonalities or divergencies were discussed to create a more complete understanding of how instructors impacted student beliefs in corequisite mathematics courses.

Positionality

I am a White, monolingual, cisgender woman in her late twenties from North Carolina. I have experience teaching as a high school mathematics teacher and an adjunct community college mathematics instructor. I interviewed participants with diverse backgrounds, and my background might have impacted the connections I made with interview participants and the replies they shared with me. Some participants could have found it difficult to open up to me about their negative experiences in mathematics classrooms given my background or because they were aware that I have taught community college mathematics. Some students might have found it difficult to open up to me because they saw me as an authority figure, while other students might have viewed me more as a peer because they were close to my age or older than me. Instructors could have been more willing to share their experiences because they may have viewed me as a peer or because I did not have any direct connection to their college, while other instructors might not have fully shared their thoughts because they viewed me as an outsider.

Although I do not have developmental mathematics teaching experience, I have taught Quantitative Literacy at a North Carolina community college and Precalculus at a North Carolina high school. This ultimately led me to be more familiar with the curriculum in these courses, which could have impacted my understanding of participant interview responses that were specific to the curriculum in these two courses. To combat this potential bias, I reviewed the course descriptions of the five course pathways to support my own understanding of the content covered in each pathway.

Findings

Quantitative Results

Descriptive statistics for the student pre-survey, post-survey and gain scores as well as the instructor survey results are presented in Table 23. On average, the pre-survey results show that students had a growth mindset, moderate math anxiety, and moderate math self-efficacy. The post-survey results show that on average students had a growth mindset, moderate math anxiety, and moderately high math self-efficacy. On average, instructors had a growth mindset, low math anxiety, and high math self-efficacy.

Table 23

Descriptive Statistics for Student and Instructor Surveys

	General Mindset		Mathematical Mindset		Math Anxiety		Math Self-Efficacy	
	μ	σ	μ	σ	μ	σ	μ	σ
Students Pre-Score	4.63	1.2	4.6	1.15	5.72	2.61	3.76	1.08
Students Post-Score	4.37	1.41	4.49	1.2	5.26	2.57	3.95	1.16
Students Gain Score	-0.26	0.83	-0.11	0.83	-0.47	2.05	0.19	0.65
Instructors Score	5.27	0.54	5.42	0.54	1.73	0.8	5.52	0.39

Differences in student gain scores among the instructors were analyzed. Descriptive statistics for mindset, math anxiety, and math self-efficacy gain scores are broken down by the

seven instructors in Table 24. An ANOVA analysis showed that there were not significant differences between the seven instructors in students' mean general mindset, mathematical mindset, and math self-efficacy gain scores. There were significant differences in students' mean math anxiety gain score across the seven instructors ($F = 2.40, p = 0.0456$). Bonferroni's post hoc test found significant differences in mean math anxiety gain scores between students taking a course taught by Cynthia, an instructor who completed the survey but did not take part in an interview, compared to students taking a course taught by Caroline ($t = 3.41, p = 0.032$). Students taking a course taught by Caroline had larger decreases in their math anxiety ($\mu = -2.1, \sigma = 1.97$) compared to their peers taking a course taught by Cynthia, who saw a small increase in their math anxiety ($\mu = 0.8, \sigma = 1.55$) over the course of the semester. Note that these instructors taught at different colleges and that Cynthia only taught Statistical Methods I and Caroline mainly taught Quantitative Literacy.

Table 24

Descriptive Statistics of Student Gain Scores by Instructor

Instructor	*n*	General Mindset		Math Mindset		Math Anxiety		Math Self-Efficacy	
		μ	σ	μ	σ	μ	σ	μ	σ
Caroline	10	-0.5	1.17	-0.27	1.22	-2.1	1.97	0.47	0.87
Cynthia	10	0	0.59	0.2	0.63	0.8	1.55	0.11	0.55
Diana	4	0	0.86	-0.25	0.5	0.75	1.5	0.1	0.8
Heith	1	-0.33	0	0.33	0	-1	0	0.58	0
Jamie	8	-0.04	0.9	-0.08	0.64	-0.875	1.25	0.31	0.61
Lizbeth	2	-0.67	0	-1	0.47	0.5	0.71	-0.58	0.24
Samantha	11	-0.45	0.78	-0.06	0.87	-0.48	2.58	0	0.48

Qualitative Results

The influence of corequisite instructors on their students' mindset, math anxiety, and math self-efficacy was explored. Student and instructor comments were split into four themes:

(1) pedagogical decisions; (2) instructor disposition; (3) the classroom environment; and (4) instructor and student interactions. Each of these themes is described in more detail below, with evidence to support each theme for both instructors and students.

Pedagogical Decisions

Some instructors made pedagogical decisions, such as their creation of collaborative environments, use of real-world problems, method for working through problems, and incorporation of study skills lessons, that influenced students' mindset, math anxiety, and math self-efficacy. Four instructors discussed how building a community in their class was important, Caroline specifically noted that "if you can create a community in your class and they're talking and they get along, that's the best." Ruby and Amy both discussed how creating spaces for students to interact can help relieve a student's math anxiety. Amy stated,

> I think the group work with getting everybody up to the board really helped them get over the math anxiety because some of them are like, 'hey, I'm actually writing on the board in a math class'. And since I've already checked their paper, or their group's paper, they know they can't get it wrong, so then they're not nervous.

Amy thinks that it's important for her students to learn from each other and that this learning can also help decrease her student's math anxiety. Several students discussed how their instructors created collaborative environments, but none referenced any impact on their beliefs.

Five instructors mentioned the importance of incorporating relatable problem-solving scenarios into their instruction. Kyle, Paige, and Trinity all worked to include real-world problems into their lessons to "show them that math is not scary" and cited the positive benefits of real-world examples, but they did not explicitly say if they thought it influenced students' mindset, math anxiety, or math self-efficacy. Ruby used real-world examples to help decrease

students' math anxiety and Valeria mentioned using them to reduce students' math anxiety and increase their math self-efficacy,

> Breaking that [math anxiety] is one of the things that I try to do. And I try to do it, too, with using real world problems…And so, I think getting that anxiety, helping them get over the anxiety, building their confidence, being relatable is so important.

Specific real-world problems Valeria discussed included painting a room in their house, buying flooring for their house, calculating paychecks and raises, and buying a car. Two students, Aaron and Cameron, both said they liked when their instructors used real-world examples and how this made their learning more fun. After taking the corequisite course, Jasmine was able to help her niece understand the math behind her mortgage and how this was a huge success moment for her. Jasmine felt that the use of real-world examples by her instructor impacted her math anxiety and math self-efficacy and had lasting impacts on her confidence even after the course was over.

Instructors discussed how they solve and work through problems and the potential influence on students. Mikayla "love[s] a choir" while she is working through problems and encourages all her students to answer the questions she asks during her lecture in a call and response style. Caroline and Valeria both liked to give students a moment to ask questions when they noticed they were getting confused looks from students. Kyle talked about how he attempts to build students' math self-efficacy through his selection of problems during a class period,

> I try to build their confidence in the easier problems and then work a little bit to the harder, so they have some success, you know. If you see that you can do a problem, then that helps build your confidence, I think.

Eight students discussed how they liked the way their instructors worked through problems, broke down the steps, and how they would word things as they were working through problems.

Ethan and Jasmine discussed how their instructor way of solving and working through problems as a class influenced their math self-efficacy. Ethan stated,

> I think the teachers did a good job explaining how to do stuff every class. So that every time I came out of class, it kind of felt like a success, I guess. Because I never felt like I left the class not knowing what we just did, you know.

It should be noted here that Ethan was describing both his corequisite and his gateway instructors. Jasmine liked the way her instructor "would word things" and "the way she broke things down." Overall, Jasmine felt that her instructor's method of explaining problems stuck with her and helped her feel more confident in her own math ability.

Seven of the instructors discussed the inclusion of mini-lessons or assignments in their corequisite course that focused on study skills and one instructor discussed how they did not have enough time to include these lessons. Mikayla wanted to focus on "the entire student, not just the math student." Even though she discussed how she incorporated lessons on growth mindset, accountability, and responsibility, she did not make any explicit comments about the effect of these lessons on students. Ruby would point students to articles about math anxiety and how to overcome it, but she did not think there was enough time in the corequisite to add in mini study skills lessons given the amount of content needed to be covered in her course.

Amy takes time to remind students that "math is not a spectator sport" and how they need to practice in order to get better. Throughout the semester, she also asks students to reflect on their current grade in the course, specifically "how they're going to maintain their grade or improve," and how this hopefully builds their confidence in their own abilities during the semester. Bianca also incorporates assignments that work to build well-rounded students, she stated,

> The way that I do my corequisite, I do a lot more journals, especially with online…but a lot of their responses in their journals is 'I've always struggled with math, but doing this class and also taking the corequisite helped me feel a little more confident about my math skills, and it, you know, gave me a little more confidence to ask for help from my instructor', and things like that. So, I definitely believe that having those additional assignments that are related to growth mindset helps to build up their confidence and feel stronger about their math skills.

Bianca thinks that the corequisite course is helpful for students that do not have confidence in their math ability and how the corequisite course "builds up their confidence in all areas."

Amy, Bianca, Kyle, Samantha, Sophia, and Trinity incorporate videos about growth mindset into their corequisite courses, and they ask students to reflect on what they learned either in class through a discussion or a brief written assignment. Sophia always makes sure to cover the growth mindset lesson in the first week of class because, as she explained,

> I want them to start all their classes with that growth mindset. Because a lot of them are already that first day going 'I can't do this', 'I cannot do this', 'Oh, my gosh! This schedule! I cannot'. And so I really push the word yet…I make them say sentences… what are you not good at…say the sentence and then always put yet at the end.

Amy, Bianca, and Samantha also showed a video introducing students to math anxiety and Amy hoped it helped them "realize they're not the only one that has math anxiety." In addition to videos, Samantha likes to reiterate that you "learn from your mistakes" and how her students may need to change what they are doing in order to be successful.

Three students (Aaron, Rebecca, and Shanelle) discussed the impact of study skills lessons incorporated by their corequisite instructor. It should be noted that all three of these

students attended Community College D, where study skills lessons are incorporated into the corequisite curriculum provided by the college. Other students from this college mentioned these lessons, but noted they were familiar with the topics, so they did not see any impact. Rebecca mentioned that the lesson on math anxiety briefly brought on more anxiety for herself because it made her worry about "bomb[ing] the course." Aaron described his experience with the study skills lessons,

> It's [math anxiety] one of those things where you see on like Tiktok or Reddit…But like I've never had it brought up to me as a problem in a math class before because math classes don't usually focus on mental health…it kind of pointed to the fact that everybody kind of has the same struggle…where it's like, 'oh, this is such a big thing, that they're talking about it in my class. So it's not just me that has these like hurdles that I have to get over. Everybody kind of has these hurdles.' And that's kind of a reassuring thing for sure.

Aaron appreciated that the study skills lessons discussed mental health topics, how that was a new experience for him in a math classroom, and how this helped his math anxiety decrease over the course of the semester. Shanelle mentioned how the growth mindset lesson taught by her instructor made her revaluate how she approached math,

> I was like, I could either just like give up now and just like stay here and be like 'I'm not good at math' or I could try and become better at math. And so, yeah. I guess that's how it's changed over the course. Obviously, it wasn't easy to change my mindset of like, a subject I was not you know fully enjoying at first, but I guess over time I actually learned to like accept and grow in my understanding of math.

Shanelle thinks the growth mindset lesson helped her adopt a growth mindset for herself.

Overall, instructors thought that the study skills lessons, specifically the lesson on growth mindset, helped positively impact students' mindset. One student agreed that this lesson positively influenced them to adopt a growth mindset. Instructors thought that their creation of collaborative environments, their use of real-world scenarios during lectures, and their incorporation of study skills lessons positively influenced students' math anxiety. Of these three pedagogical decisions made by instructors, students only recognized the use of real-world contexts and study skills lessons as having an impact on their math anxiety. In terms of students' math self-efficacy, instructors thought they positively influenced students through their use of real-world contexts, with the way they work through and solve problems during lectures, and in the study skills lessons. Students only recognized instructors' use of real-world contexts and how they work through problems in class as influences on their math self-efficacy.

Instructor Disposition

Out of the 13 instructors, 10 discussed how they try to alleviate any negative feelings students may be having in their classroom. Paige discussed how she makes sure to encourage her students whenever "they do something well or when they answer something out loud" and how she sometimes asks students to stay after class for a moment so she can "tell them what a good job they're doing." Mikayla talked about how her students need to trust her and her desire to help them in order to feel more comfortable in her classroom. Sophia and Trinity both discussed how they attempt to develop growth mindsets in their students. Sophia frequently reminded her students that "it's the journey, not the destination." Trinity hopes she "helps [her students] to have a more positive experience with the subject" and how if her students "walk out and say, 'I can do this math and all I've got to do is change my mindset,'" then she feels as if she's accomplished something. Valeria noted that to help build confidence in her students, she makes

sure to let them know "that [she's] proud of them. Because if [she doesn't], they're not going to want to do the work for [her], and [she wants] them to do the work for [her]…and a lot of them have never had that." Diana stressed the importance of making sure her students knew she cared about them and how she addresses students with math anxiety and low math self-efficacy, "I just try to be their cheerleader. Whenever I ask them a question and they answer it right, I go, 'Yesss!'…I think they recognize that by me doing little things like that, that I want them to be successful."

Amy, Bianca, Kyle, and Samantha all discussed how they praise and celebrate a student's small victories in an effort to build their students self-efficacy and to encourage a growth mindset. Bianca stated,

> Having someone tell them, 'Yes, you can do it', and 'I believe in you'…And I always tell my students, don't say I'm not a math person or I can't do math. I always tell them to eliminate that. You might not be understanding right now, or you might not have understood that concept in the past, but you can do it. Like it may take a little while, it may take longer than the rest of your classmates, but you can do it, you just had to find what makes sense to you. So yeah, definitely building them up and building up their confidence so they believe in themselves.

In addition, Bianca thinks that it is very important to show her students that she cares about them so that way students want to "do the math for her." Samantha said,

> I think it's important to point out to people how they have grown so far and that, you know, they will grow further if they continue to do what they've been doing. Like if somebody does really well on an assessment, I'll say, you know even in online, I'll put a comment that says, 'I can see you really worked hard. Let's keep that up'…Again they

> need to see the small victories, so that they know they can do it…I think with the people who kind of think they can never do math, that fixed mindset, it's really a matter of showing them those small successes.

Kyle thinks that being a corequisite instructor requires a lot of energy and that he becomes a coach and cheerleader where he's "really trying to give them confidence…Some trust in themselves that they can do it. I mean a lot of times…I have more trust in them or more faith in them that they can do it than they do." These four instructors discussed how they think their disposition and personality in the classroom helps positively influence students' math self-efficacy and mindset.

Eight students described how their instructors had the potential to influence their learning and their beliefs. Aaron and Shanelle both discussed how their instructor's personality impacted their learning. Aaron specifically discussed how "having an instructor that's approachable really went a long way." Although, neither of these students made comments specific to their change in mindset, math anxiety, or math self-efficacy. Ethan, Kaden, and Nate all mentioned the importance of their instructor's personality when asked if their instructor did anything to help them build their confidence. Ethan described his instructor as "really energetic," while Kaden described how his instructor was supportive and helpful. Nate described how his instructor really cared about the level he was at and how this helped him feel more confident in his abilities.

Cameron discussed how his instructor's personality and disposition while teaching helped reinforced his growth mindset and decrease his math anxiety. His instructor was transparent, supportive, and communicated with her students a lot. Cameron especially found that the way she approached things led him to be less stressed. Jasmine noted several times during her

interview how her instructor's enthusiasm for her learning and her consistent praise positively impacted her mindset surrounding math and her confidence in her own math ability, specifically,

> If you're excited about something, she gets just as excited about it…to hear that, it was just like, yeah, somebody's proud of me. Like that's awesome, you know…She really just like changed my whole attitude about math…I probably will never forget it ever.

When Rebecca described her instructor, she said, "she was almost like a math mom. Like what you'd want like a math professor be like…she was great." Rebecca specifically noted how her instructor influenced her and helped her math anxiety decrease over the course of the semester. Instructors and students both agreed that an instructor's personality and disposition had the potential to positively influence students' mindset, math anxiety, and math self-efficacy.

The Classroom Environment

Several instructors described how they worked to make the corequisite students feel safe and comfortable. In order to target students who have math anxiety, Ruby likes to make class "kind of goofy" and "laid back." Trinity strives to create a positive environment that in her class that reflects a growth mindset. If she has students who say, "I hate math," she tells them,

> Just put that in the garbage right now. I want you to give me the very best that you have and all those bad things, all those bad feelings about math, throw them away. They're not necessary. It's probably one of the most fun subjects you could ever have, but it's got to be taught to you the right way.

Sophia has had students tell her, "You're the first teacher that made math not scary," which has "always been [her] goal. It hasn't been for [her students] to make a 100, it's been for them to build their confidence." Sophia thinks that creating a safe space for students to learn is also important for encouraging a growth mindset in her students. Mikayla thinks that the corequisite

course provides instructors space to “create those more confident math students” and that confidence is “what makes good math students.” Mikayla has had past students say things like, “when I’m helping my kids, it's a powerful thing that I know how to do this. And now my kid looks at me like I’m superman, you know, because I know how to do this stuff.” Ruby has gotten similar feedback from students who experience success in the corequisite classroom and how this has impacted their confidence as a math student.

Students also discussed how their instructors created safe and comfortable environments. Jasmine has had math anxiety since elementary school, but she felt that her math anxiety was not as intense when taking her corequisite math course, partly due to the environment created by her instructor. Aaron described that since he felt comfortable asking questions and seeking help from his instructor, the corequisite course was “a safe space for [him] to learn, which decreased [his] anxiety a lot,” while also helping increase his own confidence in his math ability. Rebecca “felt as if [she] could do anything with her [instructor] in [her] corner” and how her instructor,

> Reflected a positive mindset to the students as well and was very like truthful. And whenever I talked to her, she was very honest with me, so I had like a good gauge of like what's really going to happen this semester. So, it was surprisingly a positive environment. I thought it was just going to be like, dank, scary, dark, and depressing, and she made it fun. She made it positive and happy, and she made working hard enjoyable.

Rebecca credits the safe environment created by her corequisite instructor as positively influencing her mindset. Kaden felt more confident by the end of the semester, and he credits the classroom environment created by his corequisite instructor, “I definitely can tell that they care and they're always trying to make sure that your work is done...And they definitely hold, my 043 [corequisite] teacher definitely holds the name for the support class…she brings the support.”

Eleven of the instructors described a growth mindset-oriented approach to mistakes and questions in their classroom, but only seven instructors discussed the influence of this approach on their students' mindset, math anxiety, and math self-efficacy. If a student has math anxiety, Ruby uses "positive reinforcement even when they get something wrong" to try to help those students. She also thinks it's important to encourage questions and if someone answers a question incorrectly, she likes to thank them "for being willing to interact and put themselves out there." If a student is struggling with their confidence in Paige's classroom, she tells them,

> Give me a chance and let's go. We work together. I'm your ally. I will work together with you to achieve your goal…but you gotta ask questions. If you don't want to ask them out loud, you can email me, and I will email you questions back, or I will send you reading. I will make a video for you.

Paige tries to make sure that her students' questions are being answered in her classroom. She also likes to encourage students and she never wants to make a student feel "put down" when they make a mistake.

One of the first things that Sophia goes over in her corequisite is fears that students have, and she finds a common one is the fear of making mistakes. In response, she likes to tell them that "if you're making a mistake, then what you're doing is learning by making that mistake, so it's not like it wasted your time because you actually learned, and that's the journey. It's not about the destination." Trinity likes to remind students that "a mistake is not a mistake, it's a steppingstone to learning…You will survive it…That's part of that growth mindset. You gotta make mistakes to learn. How you gonna learn if you get it right all the time?" Kyle reminds students that everyone is there to "[try] to get better" and he tries to get his students to a point where "they're not scared about making a mistake." He also likes to remind students that he is

imperfect just like everybody else and that he has also made mistakes. He hopes this framing of learning and mistakes can help his students realize that what they write down does not need to be perfect and that they just need to try something, even if their first attempt is wrong. These instructors believe that by framing mistakes as a part of the learning process, they will help encourage a growth mindset in their students or reinforce students' existing growth mindset.

When students come into her class with negative math self-efficacy, Valeria likes to remind her students that "it's not going to impress [her] if [they] solve a problem in two steps versus ten. If the answer is four, the answer is four. [She doesn't] care…if it takes you more steps than you think…[she's] proud." Similar to Kyle, Valeria also reiterated that she was not perfect at math. She also asked students to let her know if they see her make a mistake, and if they do point out a mistake, she makes sure to celebrate them, "Oh my gosh! Thank you! I would have never known that. I would go through this full problem and not realized it." During class, Samantha also likes to thank students for volunteering an answer. If they are a student who appears anxious or scared to make a mistake, she likes "to point out where they did things right so they can see that" and then also reminding students "how much better you're doing now than before." In addition, for those students who are the most anxious,

> When I'm walking around the room, I'm watching them more closely. Because after a couple of weeks, I know who those people are. I'll be watching them a little more closely and looking over their shoulder. If they're the one that won't ask me a question, I might linger longer in their area of the classroom because then they'll ask the question.

She hopes that by giving them space to ask questions, this can help decrease their anxiety and increase their confidence in their own math ability.

Students discussed how their instructor handled questions in the classroom and how they address students who made mistakes. Shanelle described how her instructor's method for addressing students' mistakes influenced her mindset and math self-efficacy,

> It has certainly helped me like be more confident in, this doesn't sound good, but making mistakes…Because previously if I made a mistake, I would just like hide it…not seek help for it and just accept that I was wrong. But now, I kind of like seek help if I don't understand anything, if I make a mistake, I talk about it and I try to fix it.

Aaron really liked the way his instructor approached mistakes in their classroom. He felt that it was not done in a patronizing way, and he liked how their approach "encouraged [him] to speak up more in class" because "nothing felt like a dumb question." In addition, Aaron felt that the way his instructor approached mistakes boosted his confidence because he was "able to come out of [his] shell" and he's "realizing that [he] understand[s] this a lot more than [he] thought, and that kind of decreases the anxiety." Jackson felt that his instructor's attitude surrounding mistakes reinforced his growth mindset and helped decrease his math anxiety. He stated,

> It always felt like making mistakes wasn't like a big deal. It felt like very casual, you know. If you make a mistake, just you know, study the material and don't make the mistake next time. But even if you do, you know, still not a big deal.

Nate believes that "teaching that mistakes are made along the way to getting perfect is, in my opinion, the best way to do it" and that his instructor is "doing that very well." Nate saw his growth mindset reflected in his instructor's teaching and he also found himself feeling more confident over the course of the semester as a result of this attitude. Overall, instructors and students felt that an instructor's ability to make a safe and comfortable classroom environment

and their approach to mistakes and questions in the classrooms could positively influence students' mindset, math anxiety, and math self-efficacy.

Instructor and Student Interactions

When Bianca and Caroline notice that students are appearing stressed or overwhelmed in their corequisite classes, they like to work with or meet with these students one-on-one to review the material with them. Bianca and Caroline hope that this one-on-one work with students can help lower any math anxiety their students are facing while also increasing their confidence in their math ability. In addition, Bianca felt it was very important to "[be] patient and just [continue] to build [their confidence] up" because she "think[s] that helps to alleviate some of the math anxiety that they may have." Ruby finds herself reaching out to students who make comments such as, "I'm not good at math" and she "try[s] to steer them away from that and let them know that they can be successful at math, that they can do it." Ruby finds that these students "feel much more confident in their math skills at the end of the class," and she thinks that her extra work with them helps influence this increased confidence. Ruby also makes an extra effort to check in with her female students because she remembers what it was like going through school being told she was not good enough at math and was not a math person.

Rebecca felt that her instructor "definitely influenced [her] confidence" because she was able to share her goals for the course with the instructor (i.e., making an A in the course) and work together to meet those goals. Several other students made comments about the positive effects of having their corequisite instructors walking around the room to answer questions and providing them with one-on-one attention during class and of the smaller class sizes in the corequisite, but they did not make any explicit comments about the effects of this interaction on their mindset, math anxiety, or math self-efficacy.

Two instructors, Trinity and Mikayla, both described how they ask students to send them pictures of their work when they have a question and then they annotate the work in order to answer their question or help them see where they are making their mistake. They both think this works well with their students, but they did not make any explicit comments about how this effects their mindset, math anxiety, or math self-efficacy. Ruby and Diana both think that their willingness to help students outside of class can help those students who have math anxiety. In addition, Diana always makes a point to contact those students who stop showing up for class and reminds them that she drops their lowest test grade and that she believes in them and their ability to finish the class strong. Several students mentioned their instructor's promptness when answering questions via email and how they appreciated this, but no one mentioned this in relation to their mindset, math anxiety, or math self-efficacy.

Several instructors and students commented on the lack of interaction between students and instructors in the asynchronous course format. Lizbeth referred to her asynchronous students as "ghosts" because she never hears from them, while Valeria discussed how difficult it was to see if she was having a positive effect on her asynchronous corequisite students. Ruby recognizes that logistically it would not be possible to eliminate asynchronous corequisite courses, but she "find[s] that the students who need the corequisites really do need the in-person interaction and the ones that are done asynchronously have more problems." Similarly, Bianca also thinks that students taking corequisite courses asynchronously could benefit from "more interaction with an instructor…either in-person or virtually."

Jasmine discussed how her asynchronous mathematics corequisite was the first time she "had any sort of interaction with [her] instructor" compared to her past experiences in asynchronous courses and how this really helped her feel heard and helped her succeed. On the

other hand, Jose had a negative experience taking an asynchronous course and he felt that he was "missing the interaction with the teacher." Jose had consistently high math anxiety over the course of the semester, and he thought this was due to the asynchronous course environment. Thus, the importance of instructor and student interactions should not be minimized. Only one student saw a positive influence on their math self-efficacy due to their interaction with their instructors, which contrasts slightly with instructors' view, since they thought their one-on-one interactions with students and their availability and communication with students outside of class helped positively influence students' math anxiety and math self-efficacy.

Converging the Results

In this section, the quantitative and qualitative results are merged to describe how student's mindset, math anxiety, and math self-efficacy was influenced by their corequisite instructor. The gain scores for mindset, math anxiety, and math self-efficacy were compared to student comments about if their corequisite instructors influenced how their beliefs changed over the course of the semester. If students did not make explicit comments, "N/A" was recorded in the table. During the student interviews, a distinction was not made between general and mathematical mindset. Thus, any comments made by students about their mindset were not disaggregated by general and mathematical mindset.

Mindset

Each student's survey results and the comments they made during the interview were compared to examine how students felt their corequisite instructor influenced their change in mindset during the course (see Table 25). Nick and Kaden did not make any explicit comments about how their mindset was influenced by their corequisite instructors over the course of the semester. Kaden of these students did not complete both the pre- and post-surveys, so their gain

Table 25

Examining the Influence of Corequisite Instructors on Students' Mindset

Student Name	Survey Data						Interview Data
	General Mindset			Math Mindset			
	Pre	Post	Change	Pre	Post	Change	
Jose	3.67 Moderate	5 Growth	22.22%	4 Growth	5 Growth	16.67%	Didn't Change
Nate	5.33 Growth	5 Growth	-5.56%	5 Growth	5.33 Growth	5.56%	Reinforced Mistakes and Questions
Nick	5 Growth	6 Growth	16.67%	6 Growth	6 Growth	0.00%	N/A
Ethan	6 Growth	5.67	-5.56%	5.67 Growth	5.33 Growth	-5.56%	Didn't Change
Aaron	5.33 Growth	5 Growth	-5.56%	5 Growth	5 Growth	0.00%	Didn't Change
Jackson	5.67 Growth	6 Growth	5.56%	6 Growth	6 Growth	0.00%	Reinforced Mistakes and Questions
Cameron	5.33 Growth	4.33 Growth	-16.67%	4.33 Growth	4.33 Growth	0.00%	Reinforced Instructor's Personality
Shanelle	6 Growth	6 Growth	0.00%	6 Growth	6 Growth	0.00%	Increased Mistakes and Questions Study Skills Lessons
Kaden	3.67 Moderate		N/A	3.67 Moderate		N/A	N/A
Jasmine		4 Growth	N/A		4.67 Growth	N/A	Increased Instructor's Personality
Rebecca		5 Growth	N/A		4.67 Growth	N/A	Increased Safe Environment

mindset score was unable to be calculated. Nick had no change in their math mindset and a slight increase in their general mindset. Jasmine noted that her instructor's personality helped influence her mindset in the course, while Rebecca noted that the safe environment created by her corequisite instructor influenced her mindset. Both of these students did not take both the pre- and post-survey, so a gain score was unable to be calculated. Shanelle indicated that their growth mindset increased due to the study skills lessons incorporated by their instructor and their approach to mistakes and questions. This increase was not reflected by this student's survey gain score, but it should be noted that they took the pre-survey three weeks into the semester so they could have already participated in the growth mindset lesson when they took the pre-survey.

Aaron, Ethan, and Jose discussed how they possessed a growth mindset at the beginning and end of the course and how their instructor did not influence any change in this mindset. However, the survey results did not reflect this. Aaron had a slight decrease in his growth general mindset scores, while his math mindset stayed the same. Ethan saw a slight decrease in his general and math mindset, but both his pre- and post-scores were representative of a growth mindset. Jose claimed there was no change in his mindset, but his initial growth mindset scores increased by 22.22% for his general mindset and 16.67% for his math mindset.

Cameron, Jackson, and Nate all discussed how their instructors reinforced their growth mindset. Jackson described how his instructor reinforced his growth mindset, by stating,

> I've always had this kind of mindset, but like the teacher definitely like helped reinforce it…The way they taught always kind of told us to like not worry if we're doing poorly or something, just to like keep trying your best and just like hope you do better next time.

Even though each of these students claimed that their mindset did not change, the gain survey scores showed that Cameron's general mindset score decreased, Jackson's general mindset score

increased slightly, and Nate's general mindset decreased slightly and his math mindset increased slightly. Although there were slight increases and decreases in these three students' mindset scores, their pre- and post-scores were all representative of a growth mindset.

Math Anxiety

Each student's survey scores and their comments during the interview were compared to examine how students felt their math anxiety changed over the course of the semester due to the influence of their corequisite instructor (see Table 26). Four students did not make any clear

Table 26

Examining the Influence of Corequisite Instructors on Students' Math Anxiety

Student Name	Survey Data			Interview Data
	Pre	Post	Change	
Jose	8 High	8 High	0.00%	Didn't Change
Nate	2 Low	1 Low	-10.00%	Didn't Change
Nick	1 Low	1 Low	0.00%	N/A
Ethan	7 High	3 Low	-40.00%	N/A
Aaron	6 Moderate	4 Low	-20.00%	Decreased Study skills Lessons Mistakes and Questions Safe Environment
Jackson	7 High	4 Low	-30.00%	Decreased Mistakes and Questions
Cameron	10 High	6 Moderate	-40.00%	Decreased Instructor's Personality
Shanelle	5 Moderate	7 High	20.00%	N/A
Kaden	9 High		N/A	N/A
Jasmine		10 High	N/A	Decreased Made Things Relatable Safe Environment
Rebecca		10 High	N/A	Decreased Instructor's Personality

comments about how their instructor influenced their math anxiety. Of these four students, Kaden did not have a gain score, Shanelle's math anxiety increased, Nick's math anxiety did not change, and Ethan's math anxiety decreased. Jose and Nate were classified as not having their math anxiety change over the course of the semester. Jose had consistently high math anxiety from the beginning to end of the course, and he claimed this could have been due to a lack of interaction with their instructor while taking the course asynchronously. Nate's survey results showed a 10% decrease in their math anxiety, but overall, their survey results and comments made during the interview were reflective of a low math anxiety.

Five students discussed how their math anxiety decreased over the course of the semester, which was reflected in the survey gain scores for all the students who completed both the pre- and post-survey, Aaron, Cameron, and Jackson. Aaron described how the study skills lessons, their instructor's approach to mistakes and questions, and the safe environment created by their instructor decreased his math anxiety. Cameron discussed how their instructor's personality and disposition helped decrease his math anxiety. Jackson recognized his instructor's approach to mistakes and questions as a reason why his math anxiety decreased. Jasmine attributed her decreased math anxiety over the course of the semester with her instructor's incorporation of real-world examples and their creation of a safe environment. Rebecca credited her instructor's personality and disposition for her decreased math anxiety. Even though Jasmine and Rebecca felt that their math anxiety had decreased by the end of the semester, their post-scores indicated they had high math anxiety at the end of the course.

Math Self-Efficacy

Each student's survey results and their comments from their interview were compared to see how students felt their math self-efficacy changed over the course of the semester due to the

influence of their corequisite instructor (see Table 27). Cameron, Jackson, Jose, and Nick were categorized as making no comments about their change in math self-efficacy. Cameron, Jackson, and Jose saw an increase in their math self-efficacy, while Nick saw a slight decrease in his math self-efficacy.

Table 27

Examining the Influence of Corequisite Instructors on Students' Math Self-Efficacy

Student Name	Survey Data			Interview Data
	Pre	Post	Change	
Jose	2.33 Low	3.08 Moderate	12.50%	N/A
Nate	5.25 High	5.83 High	9.72%	Increased Instructor's Personality Mistakes and Questions
Nick	4.83 High	4.67 High	-2.78%	N/A
Ethan	5 High	4.83 High	-2.78%	Increased How They Work Through Problems Instructor's Personality
Aaron	3.83 Moderate	4.5 High	11.11%	Increased Mistakes and Questions
Jackson	2.5 Low	2.67 Low	2.78%	N/A
Cameron	4.17 High	4.25 High	1.39%	N/A
Shanelle	5.42 High	5.42 High	0.00%	Increased Mistakes and Questions
Kaden	2.83 Low		N/A	Increased Instructor's Personality Safe Environment
Jasmine		3.58 Moderate	N/A	Increased How They Work Through Problems Instructor's Personality Made Things Relatable
Rebecca		4.08 High	N/A	Increased One-on-One Attention

Jasmine, Kaden, and Rebecca discussed how their math self-efficacy increased, but they did not complete both the pre- and post-surveys so gain scores were not able to be calculated to compare with their interview responses. Kaden and Jasmine both credited their instructor's personality with influencing their increased self-efficacy. Kaden also discussed how the safe learning environment created by his instructor helped increase his math self-efficacy, while Jasmine discussed how her instructor's ability to make math more relatable and how they worked through problems, especially her ability to break concepts down, also helped build her confidence in her own math ability. Rebecca discussed how the one-on-one attention she received from her instructor helped her feel more comfortable and confident in her own math ability.

Aaron claimed his instructor's approach to mistakes and questions and their ability to create a safe learning environment for their students increased his math self-efficacy, which was reflected in his survey gain score. Nate described how his instructor's personality and their approach to mistakes and questions positively influenced his math self-efficacy, and this positive increase was also reflected in his survey gain score. Ethan and Shanelle both claimed their math self-efficacy increased over the course of the semester, but Ethan's survey gain score slightly decreased and Shanelle's score showed no change. Ethan thought his increased math self-efficacy was due to his instructor's personality and how they worked through problems. Shanelle thought her instructor's approach to mistakes and questions positively influenced her math self-efficacy. As stated previously, Shanelle took the pre-survey about three weeks into the start of the semester, so this could be why her survey results and comments made in the interview do not match.

Overall, instructors had different personalities and teaching philosophies in addition to making a variety of decisions that impacted their teaching, interactions with students, and their classroom environment that could have potentially influenced students' mindset, math anxiety, or math self-efficacy. In terms of student mindset, instructors' personality, approach to questions and mistakes, incorporation of study skills lessons, and creation of a safe classroom environment all positively influence student mindset. Students also thought that instructors' approach to questions and mistakes, their incorporation of study skills lessons, their creation of a safe classroom environment, their personality, and their use of real-world contexts in problems helped decrease their math anxiety over the course of the semester. Students described how instructors' approach to questions and mistakes, their creation of a safe classroom environment, their personality, their approach to working out and describing problems, their use of real-world contexts in problems, and one-on-one attention between an instructor and student can help increase students' confidence in their own math ability. When comparing the various ways that instructors influence students' mindset, math anxiety, and math self-efficacy, we see that instructors' approach to mistakes and questions in their classroom, their ability to create a safe and comfortable environment in their classroom, and their disposition all positively influenced each belief. This result suggests that an instructor's personality and the classroom environment created by corequisite instructors can have a large influence on students' mindset, math anxiety, and math self-efficacy.

Discussion

The pedagogical decisions made by instructors teaching corequisite courses were shown to influence students' mindset, math anxiety, and math self-efficacy. Collaborative learning environments that encourage group work have been commonly used in corequisite classrooms

(Finder-Atkins & Stockdale, 2017; Logue et al. 2016), and instructors in this study found that they could help reduce math anxiety when creating a collaborative classroom environment. Although, students did not see collaborative learning opportunities as influential in dealing with their math anxiety. Corequisite students appreciate the use of relatable problems solving scenarios (Kashyap & Mathew, 2017), and the students and instructors in this study found that the inclusion of these problems helped reduce math anxiety and increase student confidence because students were familiar with the mathematics context being discussed. The speed and method that instructors worked through problems has been noted as a way to reduce student math anxiety (Raju, 2018), but this study actually found a relationship between math self-efficacy and how instructors worked through problems. Research has shown that there is value in incorporating lessons that develop study skills and time management skills (Kee & Brooks, 2018; Nicoloff, 2018; Osterholt & Barratt, 2012), and how incorporating these lessons can help decrease students' math anxiety (Kee & Brooks, 2018; Nicoloff, 2018). Instructors from this study thought that these study skills lesson influenced students' mindset, math anxiety, and math self-efficacy, while students thought only their mindset and math self-efficacy were influenced.

An instructor's disposition was also described as a major influence on corequisite students. This includes if and how instructors positively reinforce their students and if instructors cared about their students. Instructors and students found that an instructor's personality influenced student mindset, math anxiety, and math self-efficacy. Closely related to an instructor's disposition was the classroom environment created by an instructor, specifically how instructors addressed mistakes and how they created a safe environment for students. Growth mindset-oriented teaching sees mistakes as a part of the learning process and celebrates mistakes (Boaler, 2016; Moser et al., 2011). A classroom environment where mistakes are embraced can

provide students with a safe space to ask questions, which helps ensure that they fully understand a topic (Fraser, 2018; Rhew et al., 2018). Instructors and students in this study felt that an instructor's approach to mistakes and their ability to create a safe learning environment influenced student mindset, math anxiety, and math self-efficacy.

Student and instructor interactions were discussed by participants in two ways, the one-on-one interactions during class or the communication outside of the classroom. Research shows that students recommended that their math anxiety could be reduce if instructors were available outside of class (Raju, 2018). Instructors in this study agreed and they also thought that students' math self-efficacy could also be positively impacted. Although, students did not mention any positive benefits of their instructor's availability outside of class. In addition, one-on-one instruction has been described by students as helping increase their math self-efficacy and decrease their anxiety (Kim, 2016). Similarly, instructors in this study believed that one-on-one attention had the same potential, but students only noted a positive effect on their math self-efficacy.

Researchers have explored how a mindset intervention can impact community college students' math anxiety and math self-efficacy (Samuel & Warner, 2021). Researchers have also found math anxiety to be a significant negative predictor of math self-efficacy (Nicoloff, 2018). In terms of this study, student beliefs were also found to change simultaneously, specifically: (a) mindset and math self-efficacy; (b) mindset and math anxiety; or (c) mindset, math anxiety, and math self-efficacy. Results from this study differ from previous results because no students discussed how their math anxiety and math self-efficacy changed at the same time, but students did discuss how their mindset, math anxiety, and math self-efficacy all positively changed at the same time.

Limitations and Future Research

One main limitation of this study was the small number of students who took both the pre- and post-survey. This could have been the case because instructors chose not to administer the survey to their students, specifically the post-survey since it had fewer responses than the pre-survey. Another limitation of the survey was that demographic data was not collected. When seeking IRB approval, one of the colleges did not want student demographic data to be collected, thus it was not collected for students or instructors in this study. In addition, there was unequal participation across all four community colleges, specifically the lack of student interview participants from community college C. Since my study was not aiming to compare the impact of instructors on student beliefs at each college, this unequal distribution of survey and interview participants was acceptable. Future research could purposefully select survey and interview participants to have a more equal distribution between colleges and participant survey responses and demographic data could be used to purposefully select students with a broad range of backgrounds and beliefs. This research would allow for the full scope of student and instructor experiences across various backgrounds to be explored and could analyze the impact of instructors on students at each college, instead of generalizing across all four colleges. This larger study could employ a hierarchical linear model to address the quantitative research question and would also be beneficial since the colleges implemented corequisite courses in varying ways.

The finding from the ANOVA comparing mean student gain scores between instructors is something that could be impacted by confounding variables, community college and course pathway, since one instructor only taught Statistics Methods I and the other instructor taught mainly Quantitative Literacy at two different colleges. Only one of these instructors was

interviewed, so an in-depth comparison between interviews was unable to be completed. Future research of the influence of corequisite instructors could also include classroom observations in addition to interviews with students and instructors. One additional area of future research includes grouping students by whether their instructor taught study skills lessons and analyzing for differences in the change in their mindset, math anxiety, and math self-efficacy, as well as exploring and comparing the content discussed in these study skills lessons.

Conclusions

Developmental mathematics students are some of the most vulnerable mathematics students in terms of their mindset, math anxiety, and their math self-efficacy, which could be due in part to past negative experiences in math classes. Thus, a corequisite instructor should be prepared to not only teach the required mathematics content but should also work to create an encouraging environment where students feel safe and cared about. This study specifically looked at how pedagogical decisions, an instructor's disposition, the classroom environment, and the instructor and student interactions in a corequisite mathematics course can influence a student's mindset, math anxiety, and math self-efficacy. Results suggest that the largest influences on corequisite students' mindset, math anxiety, and math self-efficacy are an instructor's disposition, their approach to mistakes and questions, and their ability to create a safe learning environment. In addition, ANOVA results showed that there were significant differences between two instructor's students mean math anxiety gain scores.

CHAPTER 5: Conclusion

This chapter contains four sections. The first section is a summary of each article, including the purpose, methods, and findings of each study. The second section includes a discussion that combines the influence of corequisite courses and corequisite instructors on students' mindset, math anxiety, and math self-efficacy. Then, the factors that influence students' mindset, math anxiety, and math self-efficacy are combined with student and instructor comments about their experiences in corequisite courses related to each of these factors. The third section provides implications of the findings for community colleges, community college instructors, community colleges students, and researchers. Finally, the fourth section includes recommendations for areas of future research.

Overview of Each Article

Article One

The first article explored the experiences of students taking a corequisite course and instructors teaching a corequisite course, specifically, what characteristics of corequisite courses students and instructors found to be effective, ineffective, and what changes they would make to corequisite courses. A multiple case study design was used to analyze the student and instructor perspectives of corequisite mathematics classrooms. Semi-structured interviews were completed with 11 students and 13 instructors from four community colleges. Interviews were transcribed and coded, and then codes were grouped into four broader themes: (1) corequisite courses characteristics determined at the college and department level; (2) corequisite courses characteristics determined at the classroom level; (3) changes that have been or that could be made to corequisite courses; and (4) their overall recommendation of corequisite courses. Then, a cross-case analysis was completed to compare the student and instructor perspectives. The

student and instructor perspectives are summarized below, broken down by the four themes. Then, a summary of the cross-case analysis is given.

Student Perspective

Six students thought that corequisite courses were an effective use of their time and/or found them helpful, while nine students listed benefits of the corequisite course, specifically, the opportunity for just-in-time learning, in relation to their learning. Students had varying opinions about if the corequisite and gateway courses should be on the same or different days of the week. Overall, students felt that the content being covered in their corequisite and gateway course each week was well aligned, however, students expressed that the pace of their corequisite and gateway courses were rushed. Approximately half of the students had the same instructor teach their corequisite and gateway courses, while the other half had two different instructors for their corequisite and gateway courses. Students described advantages of both course structures, but some students voiced concerns about instructor's communication when they had two instructors.

When the experiences of asynchronous and in-person students are compared, the weekly structure for both course formats included lectures accompanied by practice. Across both course formats, students liked when real-world problem contexts were incorporated by their instructor. Timely, detailed explanations via email when asynchronous students had questions helped ensure they felt supported by their instructor. In-person students liked that their instructors allowed time for practice and liked that their instructor circulated the room during this time so students could easily ask questions. Varying amounts of group work was incorporated into in-person corequisite classrooms. In terms of their instructors' teaching, five students thought that their instructor was nice and cared about them, while eight students described how their instructor had a growth mindset-oriented teaching style and approach to questions and mistakes in their classroom.

Students made suggestions related to the scheduling of corequisite courses and the placement requirements for students in corequisite courses. Specifically, one student recommended that corequisite and gateway courses not be offered back-to-back, while another student wished there had been a way for him to opt out of attending his corequisite halfway through the semester because he was doing well and did not think he needed the corequisite course anymore. A recent change at Community College B was the adoption of eight-week semesters, and a student expressed concerns about the pace of the corequisite and gateway courses in this eight-week semester format. Finally, a student suggested that asynchronous corequisite and gateway courses should be combined into one course.

Overall, students thought that corequisite courses were effective because they provided students with extra time to study the content, which is especially beneficial for students who have been out of school for an extended period or who struggle to understand math. One student had a negative experience taking an asynchronous course, so he recommended that students take an in-person course format if they are required to take a corequisite course. Only one student did not recommend corequisite courses because they felt that their gateway instructor, the internet, or a tutor were more helpful for them than the corequisite course.

Instructor Perspective

Seven instructors believed that corequisite course design can positively affect students. Instructors had varying opinions about if the time students spent in paired corequisite and gateway courses was appropriate. Instructors described the curriculum materials they were provided by their college and expressed their concern about the pace of some of the course pathways. Instructors described advantages of having one or two instructors teach the corequisite and gateway courses. Although, instructors voiced concerns about the lack of communication

when there are two instructors and about the division between corequisite and gateway instructors when there are two departments.

Asynchronous instructors typically structured their course to include some combination of lecture videos with guided notes and assignments with practice problems based on the video. Instructors discussed decisions they made when designing the structure of their asynchronous course and described how they communicated with their asynchronous students. Some in-person corequisite instructors relied more on lecture, while others relied more on practice. Some instructors incorporated and encouraged collaborative learning environments in their classrooms. Regardless of course modality, instructors used real-world problem contexts, provided guided notes to their students, and incorporated study skills lessons in their corequisite classroom. Instructors worried about students who took asynchronous courses and believed that students do better when taking an in-person course. Overall, nine instructors discussed teaching philosophies that were rooted in growth mindset-oriented beliefs and teaching practices. Instructors also discussed how they use positive reinforcement in their classroom, create welcoming learning environments, build relationships with their students, and are flexible to their students' diverse learning needs.

Instructors discussed several suggestions related to Blackbaord, including, how the corequisite and gateway courses should be formatted, placing corequisite instructors as observers in the gateway course, and having consistent Blackboard shells. In addition, recommendations for how to redesign placement guidelines are given, as well as recommendations for scheduling corequisite and gateway courses. Instructors at Community College B had varying opinions about the effectiveness of eight-week courses, but every instructor at this college mentioned how a previous corequisite course design were one corequisite instructor was paired with multiple

gateway instructors was ineffective. Instructors across the four colleges expressed how they hoped that their college and the NCCCS allow them time to perfect the corequisite course model before making a judgment on the effectiveness of the course model and on student success in this course model, especially given how much of the implementation was during a global pandemic.

Overall, approximately half of the instructors recommended that only one instructor teach the paired corequisite and gateway courses and that students should take in-person course formats rather than asynchronous course modalities. Nine of the instructors believe that corequisite courses are working as intended, while three additional instructors offered suggestions about how to redesign the corequisite courses to make them more effective.

Cross-Case Analysis

Students and instructors discussed several advantages of the characteristics of corequisite courses and how they thought these characteristics supported students' learning. However, students and instructors both discussed how several of the corequisite courses felt rushed due to the amount of content that needed to be covered in these courses. Advantages and disadvantages of having one or two instructors teach a paired corequisite and gateway course were discussed, with students and instructors both acknowledging the importance of communication when there are two instructors. Recommendations from students and instructors about effective communication were given.

How instructors structured their asynchronous and in-person corequisite classrooms was discussed by students and instructors. Common characteristics of these corequisite classrooms included lectures, time for practice, guided notes, and real-world problem contexts. For in-person courses, group work was used by some instructors. For asynchronous courses, the importance of communication was discussed by students and instructors. There were concerns that

asynchronous courses do not effectively support corequisite students. Overall, students and instructors discussed the prevalence of a growth mindset-oriented approach to teaching, while students specifically discussed how their corequisite instructors were positive and cared about their learning. These aspects of an instructor's teaching style helped create a safe learning environment for students.

Students and instructors discussed changes that have been, or that could be, made to corequisite courses. Across both cases, recommendations were given about how to: (a) improve placement guidelines; (b) schedule corequisite and gateway courses; and (c) format corequisite and gateway courses in Blackboard, specifically, asynchronous courses. In addition, concerns about the recent adoption of eight-week courses at Community College B were discussed, and instructors also mentioned a previous ineffective course design at this college.

Overall, students and instructors recommended corequisite courses and they think that they are working as designed. Three instructors and one student offered suggestions about how to make the courses more effective, while seven instructors and one student recommended in-person course modalities rather than asynchronous course formats.

Article Two

The second article was a convergent parallel mixed methods study that investigated community college students' change in mindset, math anxiety, and math self-efficacy in a corequisite mathematics course and what characteristics of corequisite courses influence these changes. In addition, this study explored whether there are differences in students' mindset, math anxiety, and math self-efficacy when students are grouped by their grade satisfaction. The quantitative and qualitative methods and results for each of the above questions are discussed below, then a summary of the merged findings is given.

Quantitative Methods and Findings

To investigate if students' mindset, math anxiety, and math self-efficacy changed while taking a corequisite course, 47 students at four community college were administered a pre- and post-survey. The survey included a three-item mindset measure, the Single-Item Math Anxiety Scale, and the Confidence in Learning Mathematics Scale. In addition, a question asked students to self-report their final grade in their gateway course and rate their satisfaction with this grade on a scale from one to ten. Paired t-tests were computed to determine if there were significant differences in students' pre- and post-scores for each construct. Student's math self-efficacy significantly increased, while their math anxiety decreased over the course of the semester. Student's mathematical mindset did not significantly change over the course of the semester. Even though the mean general mindset pre- and post-scores were reflective of a growth mindset, student's general mindset significantly decreased. Paired t-tests also found no significant differences between students' general and mathematical mindset pre-scores, post-scores, and gain scores. Thus, students' general and mathematical mindset did not significantly differ.

An ANOVA analysis was conducted to determine if there were differences in students' mean mindset, math anxiety, and math self-efficacy post-scores given their student grade satisfaction. The three groups included: not satisfied, neutral, and satisfied. There were no significant differences among these three groups in mean general or mathematical mindset post-scores. Students who felt neutrally about their final grade or were satisfied with their final grade were more likely to have a significantly higher math self-efficacy at the end of the semester compared to those students who were not satisfied with their final grade. Students who felt neutrally about their grade had a significantly lower mean math anxiety than the students who were not satisfied with their final grade.

Finally, ANOVA analyses and Kruskal-Wallis tests were utilized to see if there were significant differences between students' pre-score, post-score, and gain score among the four community colleges and three course pathways. Among the four community colleges, the only significant result was between mean math anxiety gain scores, but Bonferroni's post hoc test did not find any significant differences. Among the three course pathways, there was a significant difference in mean math anxiety gain scores. Bonferroni's post hoc test found that students taking Quantitative Literacy had a decrease in their math anxiety compared to their peers taking Statistical Methods I who saw an increase in their math over the course of the semester. Two Samples *t*-tests and the Wilcoxon Rank Sum Test compared students' pre-scores, post-scores, and gain scores for students taking in-person and asynchronous courses. No significant differences were found, implying that students taking in-person corequisite courses did not differ from those taking asynchronous corequisite courses.

Qualitative Methods and Findings

To investigate what characteristics of corequisite courses influenced students' mindset, math anxiety, and math self-efficacy, semi-structured interviews were conducted at the end of the semester with 11 students. Interviews were transcribed and coded. Student interview comments could be categorized into two larger themes: (1) how students felt at the beginning of the semester when they signed up for a corequisite course; and (2) how the characteristics of the corequisite course influenced their mindset, math anxiety, and math self-efficacy. Three students had positive feelings and nine students had negative feelings about math when they signed up for a corequisite course. The most common negative feelings expressed by students indicated that they were "not a math person." Three students were excited when the signed up and all 11 students were worried or concerned about some aspect of the course when the signed up. The

majority of students' concerns related to them having been out of school for a while or them not knowing if they could succeed in the course.

The influence of the characteristics of a corequisite course on a student's mindset, math anxiety, and math self-efficacy was described through comments about the time spent in the corequisite course, their view of attendance and participation requirements, the effect of just-in-time learning, and their opinion of various course modalities. Seven students mentioned how the time spent in the course positively influenced them. Five students felt that it increased their math self-efficacy, while the other two students thought that it helped decrease their math anxiety and increase their math self-efficacy. One student also cited the participation requirements in their corequisite course as a reason their math self-efficacy increased. Six students discussed how the opportunities for just-in-time learning helped increase their math self-efficacy, while four of these six students also thought that the just-in-time learning helped decrease their math anxiety. One student started the semester with high math anxiety and thought that his negative experience in his asynchronous course resulted in their math anxiety staying the same throughout the course.

Merging the Results

When merging the survey and interview data, the pre-survey data was compared to student comments about their mindset, math anxiety, and math self-efficacy at the beginning of the semester. Overall, the majority of students' pre-survey scores aligned with how they described their mindset, math anxiety, and math self-efficacy during the interview. In addition, the survey scores were merged with the qualitative analysis described above to see how the change in students' beliefs compared to how they described this change and what influenced it. Every student had a growth mindset at the end of the course and all of the interview participants who commented on mindset thought that their mindset either did not change or was not

influenced by the characteristics of corequisite courses. Five students had low math anxiety at the end of the semester and their math anxiety gain scores either indicated there was no change or there was a decrease in their math anxiety. Another student had moderate math anxiety at end of the course and his gain score showed a decrease in his math anxiety. These six students either discussed how their math anxiety did not change or how it decreased during their interview. All the students who felt that their math anxiety decreased thought it was either due to the time they spent in the corequisite course or the opportunity for just-in-time learning. Three students had high anxiety at the end of the course. Nine students discussed how their math self-efficacy increased and credited the time they spent in the corequisite working on problems, the opportunity for just-in-time learning, and the participation requirements for this positive impact. All but one student had moderate or high math self-efficacy at the end of the semester, and two of the nine students who claimed their math self-efficacy increased did not have a gain score that reflected this increase.

Article Three

The third article was a convergent parallel mixed methods study that investigated the extent to which community college students' change in mindset, math anxiety, and math self-efficacy in a corequisite mathematics course varied among instructors and how corequisite instructors influenced students' mindset, math anxiety, and math self-efficacy. The quantitative and qualitative methods and results are discussed below, then a summary of the merged findings is provided.

Quantitative Methods and Findings

The survey included a three-item mindset measure, the Single-Item Math Anxiety Scale (SIMA), and the Confidence in Learning Mathematics Scale (CLMS). Forty-seven students took

both a pre- and post-survey. To investigate the extent to which community college students' change in mindset, math anxiety, and math self-efficacy in a corequisite mathematics course varied among instructor, an ANOVA analysis of the student survey responses was conducted. The results from the ANOVA analysis showed that there are not significant differences between the seven instructors in students' mean general mindset, mathematical mindset, and math self-efficacy gain scores. There were significant differences across the seven instructors in students' mean math anxiety gain scores. Bonferroni's post hoc test found that students taking a course taught by Caroline had a larger decrease in their math anxiety compared to students taking a course taught by Cynthia.

Qualitative Methods and Findings

To investigate how corequisite instructors influenced students' mindset, math anxiety, and math self-efficacy, semi-structured interviews were conducted at the end of the semester with 11 students and 13 instructors at four community colleges. Interviews were transcribed and coded, and then these codes were grouped into four larger themes: (1) pedagogical decisions; (2) instructor disposition; (3) the classroom environment; and (4) instructor and student interactions.

The pedagogical decisions made by instructors included student and instructor comments about how a collaborative environment, use of real-world examples, how the instructors solve problems, and the incorporation of study skills lessons by instructors. Two instructors thought that they could help reduce students' math anxiety by creating collaborative classroom environments where students were encouraged to work together. Real-world problems and contexts were used by two instructors to help reduce students' math anxiety, with one of these instructors also believing that they could help increase students' math self-efficacy by incorporating real-world problems. One student felt that their instructor's use of real-world

problems helped increase their math self-efficacy and decrease their math anxiety. One instructor and two students discussed how an instructor's solution method when working out problems for the class can help increase students' math self-efficacy. Study skills lessons were incorporated by the majority of instructors. Six instructors believed that these lessons could help students develop a growth mindset, with three of these instructors also believing that the study skills lessons helped decrease students' math anxiety and two of them believing it helped increase students' math self-efficacy. One student thought that these study skills lessons helped them develop a growth mindset and one student thought these lessons positively influenced their math anxiety.

Instructors' personalities were also discussed as being a potential influence on students' mindset, math anxiety, and math self-efficacy. Eight instructors mentioned how their personality and disposition can influence students. Two instructors both attempted to develop a growth mindset in their students by helping them have a positive experience in the math classroom. Six instructors felt that their high energy and positive reinforcement helped students build their math self-efficacy. One of these six instructors also thought that this helped to decrease students' math anxiety and another four of these six instructors thought that their attitude helped students develop a growth mindset. Students described their instructors as being energetic, supportive, helpful, communicative, and caring. Two students felt that their instructors helped them build their math self-efficacy, and another student thought their math anxiety decreased due to their instructor's positive energy. One student thought that his instructor's personality helped reinforce his growth mindset and decrease his math anxiety, while another student felt that their instructor helped them develop a growth mindset and helped increase their math self-efficacy.

The classroom environment created by instructors was described by students and instructors as influencing students' mindset, math anxiety, and math self-efficacy, specifically,

instructors' ability to create a safe and/or comfortable environment and their approach to mistakes and questions. Three instructors thought that their creation of a safe and comfortable classroom environment influenced students' math self-efficacy. One of these instructors thought students' math anxiety could also decreased and another thought that a student could be encouraged to adopt a growth mindset. A fourth instructor felt that a safe and comfortable learning environment helped students develop a growth mindset. One student thought that she was able to develop a growth mindset, a second thought that their math anxiety decreased, a third thought that their math self-efficacy increased, and a fourth thought that their math anxiety decreased and their math self-efficacy increased due to the classroom environment created by their instructors. Five instructors felt that their approach to questions and mistakes in their classroom helped students develop a growth mindset. Two of these five instructors also felt that this helped students' math self-efficacy increase, with one of these two instructors also thinking that they helped decrease students' math anxiety. One instructor felt that their approach to mistakes and questions influenced students to have an increased math self-efficacy, while another thought that they helped decrease students' math anxiety. Two students felt that their instructors helped reinforce or develop their growth mindset and helped increase their math self-efficacy thought their approach to questions and mistakes. A third student thought their instructor's approach helped reinforce their growth mindset and decrease their math anxiety, while a fourth felt that their math anxiety decreased and their math self-efficacy increased.

Finally, student and instructor interactions were explored, specifically, how one-on-one attention from instructors and an instructor's availability outside of class can influence students' mindset, math anxiety, and math self-efficacy. Two instructors felt that their one-on-one work with their students helped increase students' math self-efficacy and decrease their math anxiety.

A third instructor felt that their work one-on-one with students helped increase their math self-efficacy. Only one student thought that one-on-one attention positively influenced her math self-efficacy. Two instructors felt that their availability outside of class and their willingness to answer student questions helped students who had math anxiety. Several students discussed their instructor's promptness when responding to questions via email and how this positively influenced their learning, but did not discuss any impact on their mindset, math anxiety, or math self-efficacy.

Merging the Results

When merging the survey and interview data, the survey scores were combined with the interview data to see how the change in students' beliefs compared to how they described this change and what characteristic related to their instructor influenced their change in beliefs. All of the students who were interviewed had a growth mindset at the end of the course. Three students discussed how their growth mindset was reinforced by their instructor's personality or their approach to mistakes and questions, while another three students felt that their instructor's personality, ability to create a safe environment, incorporation of study skills lessons, and their approach to questions and mistakes helped them develop a growth mindset. Five students had low math anxiety at the end of the course, one student had moderate anxiety, four students had high math anxiety. Five students discussed how their instructors' personality, ability to create a safe environment, approach to questions and mistakes, incorporation of study skills lessons, and use of real-world contexts in problems helped decrease their math anxiety over the course of the semester. Two of these five students who felt that their math anxiety decreased during the semester still had high math anxiety at the end of the course, but this could be due to the fact that they have had high math anxiety since elementary school. Seven students had high math self-

efficacy at the end of the course, two students had moderate math self-efficacy, and one student had low math self-efficacy. Seven students discussed how their instructors' personality, ability to create a safe environment, one-on-one attention, approach to questions and mistakes, approach to working out and describing problems, and use of real-world contexts in problems helped increase their math self-efficacy over the course of the semester. Overall, instructors' dispositions, their approach to mistakes and questions in their classroom, and their ability to create a safe and comfortable environment in their classroom positively influenced mindset, math anxiety, and math self-efficacy. These results suggest that an instructors' disposition and the classroom environment created by corequisite instructors can have a large influence on students' mindset, math anxiety, and math self-efficacy.

Synthesizing the Articles

In this section, the results and findings from the three articles will be synthesized and discussed. First, the results from the second and third articles will be discussed to create a cohesive understanding of how students' mindset, math anxiety, and math self-efficacy was influenced either by the corequisite course structure or their corequisite instructor. Then, the characteristics of corequisite courses and instructors that influenced students' mindset, math anxiety, and math self-efficacy is compared to student and instructor comments about their experiences taking and teaching corequisite courses from the first article.

Influencing Students' Mindset, Math Anxiety, and Math Self-Efficacy

The second and third articles both explored how students' mindset, math anxiety, and math self-efficacy were influenced while taking a corequisite course. The second article specifically considered the characteristics of corequisite courses, while the third article investigated instructors' personalities, the pedagogical decisions that influenced their teaching,

the classroom environment they created, and the interactions between instructors and students. In this section, the survey and interview results from these two articles will be combined and discussed to create an overarching picture of how students' mindset, math anxiety, and math self-efficacy changed over the course of the semester. In the following sections, note that if students did not make explicit comments about their mindset, math anxiety, or math self-efficacy, "N/A" was listed in the table for that section. In addition, a distinction was not made between general and mathematical mindset during the student interviews, so any comments made by students about their mindset were not disaggregated by general and mathematical mindset.

Mindset

When discussing how the corequisite course or their corequisite instructor influenced their mindset, students fell into four categories: (a) their mindset did not change; (b) their mindset was reinforced; (c) their mindset increased; or (d) there were no explicit comments made. See Table 28 for an overview of students' mindset at the end of the course. There was no evidence of students discussing a change in their mindset for two students, Nick and Kaden. Nick had a growth mindset at the beginning and end of the course, with a slight increase in their general mindset. Kaden only took the pre-survey, and he scored in between the cutoffs for a fixed and growth mindset.

Three students (Aaron, Ethan, and Jose) did not think their mindset changed while taking a corequisite course. Aaron and Ethan had a growth mindset at the beginning and end of the course, but there were small negative differences in Aaron's general mindset and Ethan's general and mathematical mindset pre- and post-survey results. Jose had a moderate general mindset pre-score, while the remainder of his mindset scores were representative of a growth mindset. He saw about 22.22% and 16.67% increase in his general and mathematical mindset scores.

Table 28

Examining the Influence of Corequisite Courses and Instructors on Students' Mindset

Student Name	Survey Data						Interview Data	
	General Mindset			Math Mindset			Influence of Course	Influence of Instructor
	Pre	Post	Change	Pre	Post	Change		
Jose	3.67 Moderate	5 Growth	22.22%	4 Growth	5 Growth	16.67%	Didn't Change	Didn't Change
Nate	5.33 Growth	5 Growth	-5.56%	5 Growth	5.33 Growth	5.56%	N/A	Reinforced Mistakes and Questions
Nick	5 Growth	6 Growth	16.67%	6 Growth	6 Growth	0.00%	N/A	N/A
Ethan	6 Growth	5.67	-5.56%	5.67 Growth	5.33 Growth	-5.56%	Didn't Change	Didn't Change
Aaron	5.33 Growth	5 Growth	-5.56%	5 Growth	5 Growth	0.00%	Didn't Change	Didn't Change
Jackson	5.67 Growth	6 Growth	5.56%	6 Growth	6 Growth	0.00%	N/A	Reinforced Mistakes and Questions
Cameron	5.33 Growth	4.33 Growth	-16.67%	4.33 Growth	4.33 Growth	0.00%	Didn't Change	Reinforced Instructor's Personality
Shanelle	6 Growth	6 Growth	0.00%	6 Growth	6 Growth	0.00%	N/A	Increased Mistakes and Questions Study Skills Lessons
Kaden	3.67 Moderate		N/A	3.67 Moderate		N/A	N/A	N/A
Jasmine		4 Growth	N/A		4.67 Growth	N/A	N/A	Increased Instructor's Personality
Rebecca		5 Growth	N/A		4.67 Growth	N/A	Didn't Change	Increased Safe Environment

Another student, Cameron, described how he already had a growth mindset when he started taking a corequisite course, but also discussed how his instructor's personality reinforced his growth mindset. His survey results were reflective of a growth mindset at the beginning and end of the course. Rebecca and Jasmine only took the post-survey, but their results showed they had a growth mindset at the end of the course. Rebecca noted that the corequisite course did not influence her mindset, but she felt that her corequisite instructor's ability to create a safe learning environment helped her develop a growth mindset, while Jasmine believed that her instructor's personality helped her develop a growth mindset.

Nate and Jackson did not make any explicit comments about how the characteristics of their corequisite course influenced their mindset, but they both felt that their instructor's approach to mistakes and questions reinforced their own growth mindset. Survey results for these two students reflected a growth general and mathematical mindset at the beginning and end of the course. Although, Nate showed a slight decrease in his general mindset and a slight increase in his mathematical mindset, while Jackson had a slight increase in his general mindset and no change in his mathematical mindset.

Shanelle had a growth mindset at the beginning and end of the course, with no change in her pre- and post-survey scores. Although, her interview comments indicated that she believed that her instructor's approach to mistakes and questions and their incorporation of study skills lessons led her to adopt a growth mindset for herself. As mentioned in the third article, this may not have been reflected in her survey results because she took the pre-survey three weeks into the semester. Thus, she could have already participated in the growth mindset lesson when she took the pre-survey.

Overall, when discussing how their mindset was influenced while taking a corequisite course, the characteristics of corequisite courses were not cited as influencing students. Only three students felt that their corequisite instructor helped them develop a growth mindset, but another three students felt that their instructor helped reinforce their existing growth mindset. One possible reason why students did not think the corequisite course and/or their instructor influenced their mindset was because they had already been exposed to growth mindset-oriented teaching. Recent research about incorporating a growth mindset into school culture and about how to encourage growth mindset-oriented thinking in students has become more widespread (e.g., Jaffe, 2020; Ricci, 2021; Yettick et al., 2016). This potential past exposure in the school setting, combined with media that discusses mindset and how to manifest positive outcomes for oneself could be why several of the students in this study were familiar with growth mindset.

Math Anxiety

Students also discussed how the characteristics of corequisite courses and their instructor influenced their math anxiety. See Table 29 for an overview of students' math anxiety at the end of the course. There was no evidence of Kaden, Nick, or Shanelle discussing a change in their math anxiety. Kaden had high math anxiety on the pre-survey and did not take the post-survey, Nick had the same low math anxiety score at the start and end of the semester, and Shanelle's math anxiety increased 20% from the beginning to end of the semester. Jose and Nate did not think their math anxiety changed over the course of the semester. Jose had high math anxiety throughout the entire semester, and he believed this was due to the asynchronous course structure. Nate had low math anxiety at the start and end of the course.

Jasmine and Rebecca both only took the post-survey. Both reported the maximum score on the SIMA scale on the post-survey, which indicates a high math anxiety. This could be due to

Table 29

Examining the Influence of Corequisite Courses and Instructors on Students' Math Anxiety

Student Name	Survey Data			Interview Data	
	Pre	Post	Change	Influence of Course	Influence of Instructor
Jose	8 High	8 High	0.00%	Didn't Change Course Modalities	Didn't Change
Nate	2 Low	1 Low	-10.00%	Didn't Change	Didn't Change
Nick	1 Low	1 Low	0.00%	N/A	N/A
Ethan	7 High	3 Low	-40.00%	Decreased Time Spent in Course	N/A
Aaron	6 Moderate	4 Low	-20.00%	Decreased Just-in-Time Learning	Decreased Study Skills Lessons Mistakes and Questions Safe Environment
Jackson	7 High	4 Low	-30.00%	Decreased Just-in-Time Learning Time Spent in Course	Decreased Mistakes and Questions
Cameron	10 High	6 Moderate	-40.00%	Decreased Just-in-Time Learning	Decreased Instructor's Personality
Shanelle	5 Moderate	7 High	20.00%	N/A	N/A
Kaden	9 High		N/A	N/A	N/A
Jasmine		10 High	N/A	N/A	Decreased Made Things Relatable Safe Environment
Rebecca		10 High	N/A	Decreased Just-in-Time Learning	Decreased Instructor's Personality

the fact that they both described several past experiences dating back to elementary school that have impacted their math anxiety. Even though Jasmine and Rebecca both reported high math anxiety at the end of the course, they also described how their math anxiety decreased over the course of the semester. Jasmine thought that her instructor's ability to make problems relatable and their ability to create a safe classroom environment influenced her, while Rebecca felt that the opportunities for just-in-time learning in the corequisite course and their instructor's personality helped decrease her math anxiety during the semester.

Four students had high or moderate math anxiety at the start of the course, Aaron, Cameron, Ethan, and Jackson. These four students all discussed in their interviews how they thought their math anxiety decreased, and this decrease was reflected in their survey results. Ethan thought that the time spent in the course helped decrease their math anxiety, while Aaron and Cameron felt that the opportunities for just-in-time learning helped decrease their math anxiety. Jackson described how both the time spent in the course and the opportunities for just-in-time learning helped his math anxiety decrease over the semester.

Overall, when discussing how their math anxiety was positively influenced while taking a corequisite course, four students felt that the corequisite course structure and their corequisite instructor influenced them. One additional student thought that the corequisite course structure positively influenced their math anxiety and another student thought that their corequisite instructor positively influenced their math anxiety. Thus, an equal number of students cited characteristics of corequisite courses and instructors as positively influencing their math anxiety.

Math Self-Efficacy

Students described how the characteristics of corequisite courses or their corequisite instructor influenced their math self-efficacy. See Table 30 for an overview of students' math

Table 30

Examining the Influence of Corequisite Courses and Instructors on Students' Math Self-Efficacy

Student Name	Survey Data			Interview Data	
	Pre	Post	Change	Influence of Course	Influence of Instructor
Jose	2.33 Low	3.08 Moderate	12.50%	N/A	N/A
Nate	5.25 High	5.83 High	9.72%	Increased Time Spent in Course	Increased Instructor's Personality Mistakes and Questions
Nick	4.83 High	4.67 High	-2.78%	N/A	N/A
Ethan	5 High	4.83 High	-2.78%	Increased Time Spent in Course	Increased How They Work Through Problems Instructor's Personality
Aaron	3.83 Moderate	4.5 High	11.11%	Increased Just-in-Time Learning	Increased Mistakes and Questions Safe Environment
Jackson	2.5 Low	2.67 Low	2.78%	Increased Just-in-Time Learning Time Spent in Course	N/A
Cameron	4.17 High	4.25 High	1.39%	Increased Just-in-Time Learning Time Spent in Course	N/A
Shanelle	5.42 High	5.42 High	0.00%	Increased Just-in-Time Learning	Increased Mistakes and Questions
Kaden	2.83 Low		N/A	Increased Just-in-Time Learning Time Spent in Course	Increased Instructor's Personality Safe Environment
Jasmine		3.58 Moderate	N/A	Increased Time Spent in Course Participation Requirements	Increased How They Work Through Problems Instructor's Personality Made Things Relatable
Rebecca		4.08 High	N/A	Increased Just-in-Time Learning Time Spent in Course	Increased One-on-One Attention

self-efficacy at the end of the course. There was no evidence of Jose and Nick discussing how their math self-efficacy changed over the course of the semester. Nick had high self-efficacy at the beginning and end of the course, while Jose had low math self-efficacy at the beginning and moderate math self-efficacy at the end of the course. Kaden and Jackson both reported low math self-efficacy on the pre-survey. Kaden did not take the post-survey, but he described how the time spent in his corequisite course, the opportunities for just-in-time learning, his instructor's personality, and how his instructor was able to create a safe environment all helped increase his math self-efficacy as the semester went on. Jackson also reported low math self-efficacy at the end of the course, but his score increased slightly from the pre- to post-survey. He felt that the time spent in his corequisite course and the opportunities for just-in-time learning helped increase his math self-efficacy. He did not cite any influences from his instructor.

Jasmine and Rebecca did not take the pre-survey, so their gain scores were unable to be calculated. Although, both students discussed possible course and instructor influences. Jasmine reported a moderate math self-efficacy and Rebecca reported a high math self-efficacy at the end of the course. Jasmine thought that the time spent in her corequisite course, the participation requirements in the corequisite course, her instructor's method of working through and explaining problems, her instructor's personality, and her instructor's use of real-world contexts all helped increase her math self-efficacy. Rebecca thought that the time spent in the corequisite course, opportunities for just-in-time learning in the corequisite course, and the one-on-one attention provided by her instructor helped increase her math self-efficacy.

Aaron had moderate math self-efficacy at the beginning of the semester and high math self-efficacy at the end. He thought that this increase was due to the opportunities for just-in-time learning in the corequisite course, his instructor's approach to question and mistakes, and his

instructor's ability to create a safe learning environment. Four students (Cameron, Ethan, Nate, and Shanelle) had high math self-efficacy when they took the pre- and post-survey, with Nate having an increase close to 10% and the other three students having increases that were all close to zero. Ethan and Nate thought that the time spent in their corequisite course and their instructor's personality helped increased their math self-efficacy. Ethan also thought that his instructor's method of working through and explaining problems helped increase his math self-efficacy, while Nate also felt that his instructor's approach to mistakes and questions positively influenced his math self-efficacy. Cameron felt that the time spent in his corequisite course and the opportunities for just-in-time learning helped increase his math self-efficacy. Shanelle cited the opportunities for just-in-time learning in the corequisite course and her instructor's approach to questions and mistakes as positive influences on her math self-efficacy.

Overall, when discussing how their math self-efficacy was positively influenced while taking a corequisite course, seven students felt that the corequisite course structure and their corequisite instructor influenced them. Two additional students thought that the corequisite course structure positively influenced their math self-efficacy. Thus, more students described how the characteristics of corequisite courses positively influenced their math self-efficacy compared to characteristics of their corequisite instructor.

Summary

The number of times characteristics of corequisite courses and instructors were cited by students as influencing their mindset, math anxiety, and math self-efficacy is summarized in Table 31 and 32. Note that some students cited more than one feature for a given belief or cited the same feature as impacting more than one belief, so the total is representative of how many times features were described as influencing them and do not represent the number of students.

Table 31

Summary of Characteristics of Corequisite Courses that Influenced Students

	Mindset	Math Anxiety	Math Self-Efficacy	Total
Time Spent in Course	0	2	7	9
Participation Requirements	0	0	1	1
Just-in-Time Learning	0	4	6	10
Total	0	6	14	20

Table 32

Summary of Characteristics of Instructors that Influenced Students

	Mindset	Math Anxiety	Math Self-Efficacy	Total
How They Work Through Problems	0	0	2	2
Made Things Relatable	0	1	1	2
Study Skills Lessons	1	1	0	2
Instructor's Personality	2	2	4	8
Mistakes and Questions	3	2	3	8
Safe Environment	1	2	2	5
One-on-One Attention	0	0	1	1
Total	7	8	13	28

Overall, students' mindset, math anxiety, and math self-efficacy were influenced more because of a student's instructor than the corequisite course itself. This difference in influence of corequisite courses compared to instructors is mainly due to the lack of influence of the corequisite course on students' mindset. The most commonly cited characteristics of corequisite courses that influenced students' math anxiety and math self-efficacy were the time students spent in class and the opportunities for just-in-time learning. The most commonly cited reasons for instructors positively impacting students' mindset, math anxiety, and math self-efficacy was their personality, their growth mindset-oriented approach to questions and mistakes, and their ability to create a safe learning environment. These three factors fall under the instructor

disposition and classroom environment themes, which indicates that these two themes hold a considerable influence on students' mindset, math anxiety, and math self-efficacy.

Researchers have explored how a mindset intervention can impact community college students' math anxiety and math self-efficacy (Samuel & Warner, 2021) and showed how math anxiety was a significant negative predictor of math self-efficacy (Nicoloff, 2018). Students in this study discussed how corequisite courses and instructors influenced their beliefs. One student discussed how their math self-efficacy was positively influenced, two students discussed how their mindset and math self-efficacy was positively influenced, two students discussed how their math anxiety and math self-efficacy was positively influenced, and four students discussed how their mindset, math anxiety, and math self-efficacy was positively influenced. Only two students in this study did not believe that corequisite courses or instructors positively influenced their mindset, math anxiety, or math self-efficacy.

The Characteristics of Corequisite Course

In the second article, students discussed four factors that have the potential to influence their mindset, math anxiety, and math self-efficacy. Three of these factors, time spent in corequisite courses, just-in-time learning, and the various course modalities were discussed in the first article. This section will combine the student and instructor opinions about the effectiveness of these three factors with the student opinions about the potential influence of these three factors on their mindset, math anxiety, and math self-efficacy.

Time Spent in the Course

The amount of time students spent a week in their corequisite and gateway course varied depending on what course pathway students were enrolled in, and ranged from six to nine total contact hours. Some instructors worried the amount of time students spent in their corequisite

and gateway courses each week was overwhelming for students, especially for the Precalculus Algebra pathway that met for nine hours a week. Comments from students mitigate this concern and suggests that the time spent in corequisite courses is beneficial for students. Several students were initially annoyed about how many hours a week they had to be in class, but within the first few weeks of the course they understood why the courses were set up this way and how it was beneficial for them. Specifically, some students liked that they were doing math every day of the week because it gave them plenty of time to practice and ask questions, while also helping ensure they were not forgetting material from one class to the next. In addition, students discussed how the time spent in the corequisite course helped increase their own confidence in their mathematics ability which also helped decrease their mathematics anxiety. These findings about the benefits of the amount of time students spent in their corequisite and gateway course align with findings from Atkins and Beggs (2017), who suggested that frequent, sometimes daily, access to mathematics faculty provides fewer opportunities for unexpected challenges that could negatively impact students.

Just-in-Time Learning

Just-in-time learning allows students to complete their developmental and college-level mathematics courses simultaneously without making students feel like they were taking an additional developmental course that was setting them back in regard to their progress towards graduation (Kashyap & Mathew, 2017; Logue et al., 2016). Just-in-time learning describes the opportunity for the necessary developmental curriculum to be offered in the corequisite course that aligns to the content being discussed that week in a student's gateway course. This course feature has commonly been regarded as advantageous to students because it helps build their foundational mathematics knowledge and increases their confidence in their math ability (Kim,

2016; Mireles et al., 2014; Mullins, 2018), and results from this study concur. Specifically, students felt that the opportunities for just-in-time learning provided by their corequisite course was a key factor in helping them learn the content in their gateway course, as well as helping decrease their math anxiety and increase their math self-efficacy over the course of the semester.

Asynchronous Courses

Jose did not have a positive experience taking an asynchronous corequisite course. He was very confused by the course layout, specifically, what order the assignments should be completed. In addition, Jose did not think there was good communication with his instructor because when he would reach out with a question about a concept, the response from his instructor would be delayed and would include a YouTube video rather than a specific response to his question. Jose had high math anxiety when he started and ended the course, and he believes that his high math anxiety throughout the corequisite course was due to his experience taking it asynchronously. Jose does not recommend asynchronous corequisite courses and suggests that future corequisite students take an in-person course instead. Seven instructors agreed with Jose's suggestion of taking in-person corequisite courses rather than asynchronously.

Jasmine had a completely different experience in her corequisite compared to Jose. Her instructor recorded lectures of herself teaching the material, which made a huge difference for her because it helped her feel connected in the online environment. In addition, her instructor provided students with guided notes that frequently included real-world examples, which helped her understand the material as she watched the recorded lectures. When Jasmine reached out to her instructor via email with questions, she received supportive and detailed responses. Jasmine described how her instructor's personality helped her develop a growth mindset and helped increase her math self-efficacy. In addition, she also thought the time spent in the corequisite

course, the participation requirements, her instructor's ability to make things relatable, and how her instructor worked through problems during their recorded videos helped increase her math self-efficacy. She felt that her instructor's ability to make concepts relatable and create a safe learning environment helped decrease her math anxiety.

Jose and Jasmine had differing experiences taking an asynchronous corequisite course. Jose's negative experience and Jasmine's positive experience influenced their mindset, math anxiety, and math self-efficacy in different ways. Contrary, when all the students taking asynchronous and in person courses were compared, Two Sample *t*-tests and the Wilcoxon Rank Sum Tests found no significant differences in students' mindset, math anxiety, and math self-efficacy for their pre-scores, post-scores, and gain scores. These results imply that students taking in person and asynchronous corequisite courses did not have different mindset, math anxiety, and math self-efficacy at the beginning or end of the course.

Corequisite Instructors

In the third article, students and instructors discussed how an instructor's pedagogical decisions, disposition, classroom environment, and interactions with students influenced students' mindset, math anxiety, and math self-efficacy. Characteristics of these four larger themes were also discussed in the first article. This section will combine the student and instructor opinions about the effectiveness of these characteristics with the student and instructor opinions about the potential influence of these characteristics on their mindset, math anxiety, and math self-efficacy.

Pedagogical Decisions

The pedagogical decisions made by instructors were described by participants in the third article in four ways, the creation of a collaborative learning environment, the use of real-world

contexts, how instructors worked through problems, and the incorporation of study skills lessons. Creating a collaborative environment in corequisite classrooms is a common pedagogical decision (Finder-Atkins & Stockdale, 2017; Logue et al. 2016). The instructors in this study who thought that group work had the potential to help reduce students' math anxiety utilized group work in their corequisite classroom, while other instructors did not utilize group work. Students found their instructors' use of individual, peer, and group work to be effective. However, students did not think that their instructor's use of a collaborative environment influenced their mindset, math anxiety, or math self-efficacy.

An instructor's use of real-world contexts and relatable problem scenarios were cited by students as an effective teaching practice in corequisite courses, which is consistent with previous findings from Kashyap and Mathew (2017). In addition, students and instructors in this study found that the inclusion of these problems helped reduce math anxiety and increase student math self-efficacy. How fast instructors work through problems and the method they use when solving has been found to reduce students' math anxiety (Raju, 2018). Although, this study found that these features related to how instructors solve problems were noted by students as an influence on their math self-efficacy. Overall, students in this study thought that their instructor's speed of solving problems and their solution methods were effective.

Findings show that incorporating lessons about how to develop study skills and time management skills has the potential to decrease students' math anxiety (Kee & Brooks, 2018; Nicoloff, 2018). Instructors in this study incorporated study skills lessons that focused on growth mindset, time management, accountability, responsibility, and math anxiety. During these lessons, students typically watched a video, independently reflected, and then shared and discussed their reflections during in-person classes. In asynchronous courses, discussion boards

were used in place of whole class discussions. Instructors from this study felt that study skills lesson had the potential to influence students' mindset, math anxiety, and math self-efficacy, while students only thought that their mindset and math self-efficacy were influenced.

Instructor's Disposition and the Classroom Environment

An instructor's disposition and the classroom environment they created was also described as two major influences on corequisite students. Students described how they thought their corequisite instructor was positive and encouraging, how it was obvious their corequisite instructor cared about them and their learning, and how they created safe, comfortable learning environments. Instructors made similar comments about their teaching styles compared to the student perspective. Several instructors also described how they frequently used positive reinforcement in the classroom, with some instructors saying how they acted as "cheerleaders" for their students. Students felt comfortable asking questions in their corequisite classrooms and they thought that their instructors encouraged mistakes. Instructors described how they saw mistakes as another step in the learning process, which they frequently expressed to students in a hope that their mindset would be influenced. Celebrating mistakes as a part of the learning process is reflective of growth mindset-oriented teaching (Boaler, 2016; Moser et al., 2011), and helps create a classroom culture where students are comfortable asking questions (Fraser, 2018; Rhew et al., 2018). Overall, instructors created classrooms that were rooted in growth mindset teachings, where students felt safe, and where students felt encouraged and cared about.

Instructors and students believed that an instructor's personality and disposition, an instructor's approach to mistakes and questions, and an instructor's ability to create a safe learning environment influenced students' mindset, math anxiety, and math self-efficacy. In addition, an instructor's personality and their approach to questions and mistakes were the two

most cited characteristics of instructors that influenced students' mindset, math anxiety, and math self-efficacy. Thus, an instructor's disposition, their growth mindset-oriented approach to mistakes and questions, and their ability to create a safe learning environment for their students are the three largest influences on students' mindset, math anxiety, and math self-efficacy.

Student and Instructor Interactions

Student and instructor interactions were discussed by participants in the third article in two ways, the one-on-one interactions during class or the communication outside of the classroom. One-on-one instruction is one factor of corequisite courses that can help increase students' math self-efficacy and decrease their anxiety (Kim, 2016). Instructors in this study thought that one-on-one work with students had the potential to increase students' math self-efficacy and decrease their math anxiety. One student noted a positive effect of one-on-one attention from their instructor on their math self-efficacy. Even though no other students noted positive benefits of one-on-one attention in terms of their beliefs, students did mention how they thought the smaller class sizes in corequisite classrooms were beneficial because they allowed for opportunities for students to interact with their instructor one-on-one.

Instructor interactions with students and their availability to help students outside of class were primarily discussed in asynchronous contexts. Asynchronous students described aspects of effective communication with their instructors. These aspects included responses that were prompt, detailed, and supportive. Instructors described how they were always willing to meet with students to help answer their questions. Several instructors described how they would ask students to send them pictures of their work when they were coming across a mistake, which instructors would then annotate to point out where the student was making a mistake and would also work through the correct solution. Instructors found this to be an effective way to answer

their students' questions and to help them see where they are making their mistake. Instructors in this study thought that their students' math anxiety could be decreased and math self-efficacy could be increased due to their availability and communication outside of the classroom. Although, students did not think their instructor's availability outside of class influenced their mindset, math anxiety, or math self-efficacy.

Implications

Community Colleges

Instructors commonly notice a few students every semester who do not need to be in the corequisite course but who are placed into corequisite mathematics courses. The mathematics placement requirements for community colleges students are largely based on how well that student did in high school across all subjects. Revisions to the placement guidelines that place students based on their mathematics ability should be considered and implemented by the colleges. The placement into corequisite courses can be discouraging for students, but this study found that students enrolled in corequisite courses had increased self-efficacy, decreased math anxiety, and were able to successfully complete the course.

Students in this study were often worried when they signed up for their corequisite courses, specifically, that they would fall behind and that they would not be able to keep up with the material. These concerns quickly disappeared when taking corequisite courses because they realized that the point of these courses was to help them be successful students and to give them time to develop their understanding of the material. If advisors and instructors help student understand the benefits and purpose of corequisites, they could enter the course with a more positive attitude. Having a more positive attitude when beginning their corequisite course could impact student success in the early weeks of the semester.

Asynchronous courses were not a popular course design among instructors. They worried about the lack of interaction between themselves and their students, specifically, that corequisite students need this interaction to be successful. Professional development based on Stavredes's (2011) recommendations about effective online teaching could be provided by the colleges to help instructors learn how to interact with students and about how to increase student engagement in online environments. In addition, professional development about how to incorporate growth mindset-oriented teaching practices and how to encourage students' learning in corequisite courses could be provided. Growth mindset-oriented teaching was described by students as being effective. Additionally, instructors' ability to create safe learning environments where questions and mistakes were celebrated were cited as helping students develop a growth mindset, decrease their math anxiety, and increase their math self-efficacy. Thus, it is important that community colleges help ensure that corequisite instructors are capable of building these types of learning environments.

When the influence of the characteristics of corequisite courses on students' mindset, math anxiety, and math self-efficacy was explored, just-in-time learning was an important characteristic that helped increase students' math self-efficacy and decrease their math anxiety. Thus, it is imperative that colleges understand the importance of just-in-time learning and work to make sure that this characteristics of corequisite courses is never threatened. One college used to pair one corequisite instructor with multiple gateway instructors, which ensures just-in-time learning never happens for the corequisite students. Thus, this course design should not be considered by colleges because then one of the most effective influences on students is being removed. In addition, colleges and departments can automatically list corequisite instructors as observers in their paired gateway instructors Blackboard shell. This helps ensure that the

corequisite instructor knows what pace the gateway course is moving so that they would be able to plan their course lessons more effectively.

When considering the curriculum for corequisite courses, the content and pace of the Quantitative Literacy, Statistical Methods I, and Precalculus Algebra course pathways should be re-evaluated. This includes discussing and evaluating if there is content in the gateway courses that can be eliminated, which would ultimately decrease the amount of content that needs to be covered in the corequisite course. In addition, given that the study skills lessons incorporated by some of the instructors in this study helped positively influence students, colleges and mathematics departments should consider building out lessons specific to these study skills that instructors can then implement into their classroom. This will ensure these lessons are being consistently implemented across the five pathways.

Corequisite courses were a new course design developmental mathematics departments and instructors across the state had to implement in recent years, while also contending with a global pandemic that prompted a shift to online learning. Instructors are tired. Courses are finally shifting back to primarily in-person course modalities, and instructors want time with the current corequisite course design before the NCCCS or their college decide to redesign developmental courses again. In addition, instructors did not always feel like their opinions about the implementation of corequisite courses were being valued and heard by their college. Thus, colleges and departments should consider elevating the voices of their master teachers and listening to their suggestions about what needs to change to make the courses more effective.

Community College Instructors

Corequisite instructor's pedagogical decisions can positively influence students' mindset, math anxiety, and math self-efficacy. Students liked when instructors provided detailed

responses and problem solutions, as well as when they incorporated real-world contexts into these problems. This helped make the learning process more fun for students and helped them translate what they were learning in class to their lives outside of the classroom. In addition, students liked when study skills lessons were incorporated into their corequisite classrooms and appreciated that mental health was being discussed in their math classroom. The growth mindset lesson is especially important as it was cited by a student in this study as helping them develop a growth mindset at the beginning of the course that ultimately helped influence their mindset and learning throughout the semester. Thus, the growth mindset study skills lesson should be incorporated into corequisite courses in the first week of class if possible.

In addition, a corequisite instructor's teaching style can positively influence students' mindset, math anxiety, and math self-efficacy. Students responded well to instructors who obviously cared about them, praised them, and encouraged them. In addition, students liked instructors who considered mistakes to be a part of the learning process and did not make them feel discouraged when they made a mistake. In addition, instructors should consider how to create safe learning environments for their students and should reflect on how to create this safe space in their classroom. One way this was accomplished by the instructors in this study was through their use of positive reinforcement. Surveying students throughout the semester could help instructors reflect on if a safe learning environment has been created for their students.

Corequisite courses are potentially an unfamiliar class format for students. Thus, it is important that instructors help students understand the purpose of the course and the possible benefits of the course in the first few weeks of class. Instructors could share the results from this study with their students about the benefits of corequisite courses, specifically that the time students spend in their corequisite course and the opportunities for just-in-time learning that it

provides are two factors that help decrease students' math anxiety and increase their math self-efficacy over the course of the semester. By sharing these results with their students, instructors can help encourage student buy-in to the course format.

Since just-in-time learning is cited by students as being a positive influence on students' math anxiety and math self-efficacy, it is important that instructors are providing the most effective just-in-time learning as possible. When there is only one instructor teaching both the corequisite and gateway course, this is not as big of a concern because the instructor sees their students in both classes and can adjust as needed to ensure the courses are aligned. When there are two instructors teaching the corequisite and gateway course, frequent communication is imperative. This ensures that the two courses are aligned and that students are receiving just-in-time instruction. These two instructors should communicate at least once a week, and this communication should involve the content being covered, how it is being taught, and any changes to the original course pacing guide. If colleges do not automatically place corequisite instructors as observers in their paired gateway instructor's Blackboard course, the gateway instructor should do this. That way if the course pacing is changed in any way, the corequisite instructor can see this change.

Community College Students

Instructors were worried about the outcomes for students who signed up for asynchronous corequisite courses, and one student in this study had a particularly negative experience taking an asynchronous course. Thus, when signing up for their corequisite and gateway course, students should consider what type of learning environment they do well in. If a student feels comfortable in math classrooms and believes they are a self-sufficient learner, then an asynchronous corequisite and gateway pairing could be a good fit for them. If a student has a

fixed mindset, suffers from math anxiety, or has low math self-efficacy, then synchronous or in-person corequisite options should be considered. Students should not be discouraged by the number of hours of math they are required to sign up for, because this time spent in the corequisite course has been cited by students as decreasing their math anxiety and increasing their math self-efficacy. Thus, even if the time they are required to spend in a math classroom is initially discouraging, students should recognize the positive benefits and outcomes associated with this extra time.

Researchers

This study has implications for researchers that want to assess the effectiveness of corequisite course models. In past studies (e.g., Kashyap & Matthew, 2017; Logue et al., 2016) the effectiveness of corequisite courses has been determined by analyzing students' final course and exam grades. This study looked more in depth at the student and instructor experiences, as well as the influence of the corequisite course and instructor on students' mindset, math anxiety, and math self-efficacy. This study shows how the placement of students in corequisite courses has the potential to influence their mindset, math anxiety, and math self-efficacy. In addition, researchers should consider if colleges incorporate study skills lesson into their curriculum and if there are differences in student success when these lessons are incorporated.

Recommendations for Future Research

This study was conducted at four North Carolina community colleges located in urban areas. Future research studies could explore if these results are consistent at smaller, rural community colleges or in other states. There were two methodological limitations that future research could explore. First, instructors were asked to administer the survey in the first two weeks of the semester. If instructors administered the survey at the end of the second week,

students' mindset, math anxiety, and/or math self-efficacy could have already been influenced by the characteristics of corequisite courses or by their instructors. In a future study, the pre-survey should be administered the very first day of class so that the most accurate representation of students' beliefs when they began the course is collected. Second, the interviews were semi-structured and did not include questions that specifically asked students about their beliefs at the beginning of the semester. Students were asked about their concerns when signing up for a corequisite course, but pre-interviews could be added to the study design in order to better understand how students' beliefs changed over the course of the semester. In addition, it was sometimes unclear in the interviews if students were talking about their math anxiety or their anxiety in general. Future studies could more deeply explore student beliefs when they began the course and address this distinction between anxiety and math anxiety.

In terms of how the participants were sampled, there were an unequal number of students and instructors who were surveyed and interviewed across the four colleges. In addition, there was a limited number of student and instructor interview volunteers, so interview participants were not able to be purposefully sampled. This meant that every student and instructor who volunteered was interviewed, regardless of their survey results or the community college they attended or taught at. There were no student interviewees from Community College C, with the majority of students being from Community College D. Two suggestions for future research are described below that would address these concerns about unequal sampling across the colleges.

First, an embedded, multiple case study could compare the student and instructor perspectives of the corequisite course model within each college. This study would provide the opportunity for comparisons among institutions, which was beyond the scope and ability of this study due to the sampling concerns. This embedded, multiple case study would require a larger

number of participants that are equally distributed across colleges and within each case, students and instructors. Second, a future study could analyze the impact of instructors on students' achievement, mindset, math anxiety, and math self-efficacy at each college via a hierarchical linear model. This study would require a larger sample of students and instructors from various community colleges. In this current study, results were generalized across all four colleges, but this future study would account for the various ways that colleges implemented corequisite courses.

A limitation of this study was that student and instructor comments about their experiences in corequisite classrooms were unable to be verified via classroom observations. Future research that analyzes the experiences of students in corequisite classrooms and instructors teaching of corequisite courses could also utilize classroom observations in addition to interviewing students and participants. An observation protocol could be created based on the interview responses in this study about what students and instructors found to be effective teaching practices, characteristics of corequisite courses that influenced their beliefs, or characteristics of instructors and their teaching that influenced student beliefs.

Study skills lessons that focused on time management, how to study for a math test, math anxiety, growth mindset, etc. were used by some of the instructors. The amount of study skills lessons incorporated by instructors varied, and not all the instructors in this study incorporated study skills lessons into their corequisite classrooms. A future study could analyze the impact of these study skills lessons more closely by grouping students based off whether their instructor used study skills lessons and testing for differences in students' mindset, math anxiety, and math self-efficacy, as well as student achievement. Observations of instructors could also be used to capture how study skills lessons were incorporated into corequisite classrooms.

Closing Remarks

Corequisite mathematics courses have recently been implemented at community college classrooms across North Carolina. This study has detailed what characteristics of corequisite courses students and instructors find effective and what changes they would make to the corequisite course model to make it more effective. In addition, findings indicated that characteristics of corequisite courses positively influenced students' math self-efficacy and helped decrease their math anxiety, while corequisite instructor's pedagogical decisions, disposition, the classroom environment they created, and their interactions with students were found to help students develop a growth mindset, decrease their math anxiety, and increase their math self-efficacy.

REFERENCES

Acee, T. W., Barry, W. J., Flaggs, D. A., Holschuh, J. P., Daniels, S., & Schrauth, M. (2017). Student-perceived interferences to college and mathematics success. *Journal of Developmental Education, 40*(2).

Alexander, L., & Martray, C. (1989). The development of an abbreviated version of the Mathematics Anxiety Rating Scale. *Measurement and Evaluation in Counseling and Development*, *22*(3), 143-150.

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science*, *11*(5), 181-185.

Atkins, C., & Beggs, C. T. (2017). Commuting the math sentence: Accelerating developmental mathematics using the co-requisite model. *NADE Digest*, *9*(1), 20-24.

Atkins, C., & McCoy, A. (2016). A co-requisite model for developmental mathematics: Innovative pathway leads to positive outcomes for education majors. *Educational Renaissance, 5*(1), 13-25.

Bailey, T., Jeong, D. W., & Cho, S. W. (2010). Referral, enrollment, and completion in developmental education sequences in community colleges. *Economics of Education Review*, *29*(2), 255-270.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191.

Beilock, S. L., Gunderson, E. A., Ramirez, G., & Levine, S. C. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences*, *107*(5), 1860-1863.

Bitner, J., Austin, S., & Wadlington, E. (1994). A comparison of math anxiety in traditional and nontraditional developmental college students. *Research and teaching in developmental education*, 35-43.

Boaler, J. (2015). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. John Wiley & Sons.

Bonham, B. S., & Boylan, H. R. (2011). Developmental mathematics: Challenges, promising practices, and recent initiatives. *Journal of Developmental Education, 34*(3), 2-4.

Broadbooks, W. J., Elmore, P. B., Pedersen, K., & Bleyer, D. R. (1981). A construct validation study of the Fennema-Sherman Mathematics Attitudes Scales. *Educational and Psychological Measurement*, *41*(2), 551-557.

Brougham, L., & Kashubeck-West, S. (2017). Impact of a growth mindset intervention on academic performance of students at two urban high schools. *Professional School Counseling*, *21*(1), 1-9.

Burnette, J. L., Russell, M. V., Hoyt, C. L., Orvidas, K., & Widman, L. (2018). An online growth mindset intervention in a sample of rural adolescent girls. *British Journal of Educational Psychology*, *88*(3), 428-445.

Campbell, P. S. (2015). *Self-efficacy in a co-requisite model of developmental mathematics and college algebra: A qualitative analysis of student perceptions* [Doctoral dissertation, Texas Tech University].

Campbell, E., & Cintron, R. (2018). Accelerating remedial education in Louisiana. *New Directions for Community Colleges*, *2018*(182), 49-57.

Chen, X., & Simone, S. (2016, September). *Remedial coursetaking at U.S. public 2-and 4-Year institutions: Scope, experiences, and outcomes: Statistical analysis report.* National

Center for Education Statistics. U.S. Department of Education. Retrieved from https://nces.ed.gov/pubs2016/2016405.pdf

Childers, A. B., Lu, L., Hairston, J., & Squires, T. (2021). Impact and effects of co-requisite mathematics remediation. *PRIMUS*, *31*(2), 167-183.

Claro, S., Paunesku, D., & Dweck, C. S. (2016). Growth mindset tempers the effects of poverty on academic achievement. *Proceedings of the National Academy of Sciences*, *113*(31), 8664-8668.

Clyburn, G. M. (2013). Improving on the American dream: Mathematics pathways to student success. *Change: The Magazine of Higher Learning, 45*(5), 15-23.

Creswell, J. W., & Plano Clark, V. (2018). *Design and conducting mixed methods research* (3rd ed.). SAGE Publications, Inc.

Degol, J. L., Wang, M. T., Zhang, Y., & Allerton, J. (2018). Do growth mindsets in math benefit females? Identifying pathways between gender, mindset, and motivation. *Journal of Youth and Adolescence*, *47*(5), 976-990.

Dweck, C. S. (2008). *Mindset: The new psychology of success*. Penguin Random House LLC.

Dweck, C. S., Chiu, C. Y., & Hong, Y. Y. (1995). Implicit theories and their role in judgments and reactions: A word from two perspectives. *Psychological inquiry*, *6*(4), 267-285.

Edley, C. (2017, June 5). *At Cal state, algebra is a civil rights issue.* EdSource. Retrieved from https://edsource.org/2017/at-cal-state-algebra-is-a-civil-rights-issue/582950

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education*, *7*(5), 324-326.

Finder-Atkins, C., & Stockdale, C. L. (2017). An investigation of placement measures and student performance in a co-requisite mathematics pathway. *Research and Teaching in Developmental Education, 33*(2), 5-20.

Fraser, D. M. (2018). An exploration of the application and implementation of growth mindset principles within a primary school. *British Journal of Educational Psychology*, *88*(4), 645-658.

Ganga, E., Mazzariello, M., & Edgecombe, N. (2018). Developmental education: An introduction for policymakers. Denver, CO: Education Commission of the States. Retrieved from https://postsecondaryreadiness.org/developmental-educationintroduction-policymakers/

Guy, G. M., Cornick, J., & Beckford, I. (2015). More than math: On the affective domain in developmental mathematics. *International Journal for the Scholarship of Teaching and Learning, 9*(2).

Hacisalihoglu, G., Stephens, D., Stephens, S., Johnson, L., & Edington, M. (2020). Enhancing undergraduate student success in stem fields through growth-mindset and grit. *Education Sciences*, *10*(279).

Hennessey, M. M., Kupczynski, L., Hall, K. S., & Peel, L. (2021). Effectiveness of developmental mathematics models on college algebra. *International Journal of Education*, *9*(1).

Jaffe, E. (2020). Mindset in the classroom: Changing the way students see themselves in mathematics and beyond. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *93*(5), 255-263.

Jimenez, L., Sargrad, S., Morales, J., & Thompson, M. (2016). Remedial education: The cost of catching up. *Center for American Progress*.

Kashyap, U., & Mathew, S. (2017). Corequisite model: An effective strategy for remediation in freshmen level quantitative reasoning course. *Journal of STEM Education: Innovations & Research, 18*(2).

Kee, C. E., & Brooks, J. S. (2018). Exploring developmental mathematics from faculty members' perspectives: How internal and external dynamics influence student success in a community college. *Asia Pacific Journal of Social and Behavioral Sciences*, *15*.

Kim, M. (2016). Just-in-time pedagogical support in co-requisite remedial models in terms of student learning, mathematics, self-efficacy and achievement. *IOSR Journal of Research & Method in Education*, *6*(5), 36-42.

Kosiewicz, H., Ngo, F., & Fong, K. (2016). Alternative models to deliver developmental math: Issues of use and student access. *Community College Review, 44*(3), 205-231.

Limeri, L. B., Carter, N. T., Choe, J., Harper, H. G., Martin, H. R., Benton, A., & Dolan, E. L. (2020). Growing a growth mindset: Characterizing how and why undergraduate students' mindsets change. *International Journal of STEM Education*, *7*(1), 1-19.

Linneberg, M. S., & Korsgaard, S. (2019). Coding qualitative data: A synthesis guiding the novice. *Qualitative Research Journal*.

Logue, A. W., Douglas, D., & Watanabe-Rose, M. (2019). Corequisite mathematics remediation: Results over time and in different contexts. *Educational Evaluation and Policy Analysis*, *41*(3), 294-315.

Logue, A. W., Watanabe-Rose, M., & Douglas, D. (2016). Should students assessed as needing remedial mathematics take college-level quantitative courses instead? A randomized controlled trial. *Educational Evaluation and Policy Analysis*, *38*(3), 578-598.

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in cognitive sciences*, *16*(8), 404-406.

McCabe, J. A., Kane-Gerard, S., & Friedman-Wheeler, D. G. (2020). Examining the utility of growth-mindset interventions in undergraduates: A longitudinal study of retention and academic success in a first-year cohort. *Translational Issues in Psychological Science*, *6*(2), 132.

Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis: A methods sourcebook* (3rd ed.). SAGE Publications.

Mills, I. M., & Mills, B. S. (2018). Insufficient evidence: Mindset intervention in developmental college math. *Social Psychology of Education*, *21*(5), 1045-1059.

Min, A. & Eugene, N. (2019) Co-requisite statistics course for non-STEM students: Does it work? In D. Morgan, K. Feagin, & N. S. Shapiro (Eds.), *Reforming mathematics in Maryland: Stories from the journey* (pp. 65-71). University System of Maryland.

Mireles, S. V., Acee, T. W., & Gerber, L. N. (2014). FOCUS: Sustainable mathematics successes. *Journal of Developmental Education*, 26-36.

Moser, J. S., Schroder, H. S., Heeter, C., Moran, T. P., & Lee, Y. H. (2011). Mind your errors: Evidence for a neural mechanism linking growth mind-set to adaptive post error adjustments. *Psychological science*, *22*(12), 1484-1489.

Mullins, S. (2018). *The effectiveness of the co-requisite model in preparing college students for math courses* [Doctoral Dissertation, Murray State University]. Murray State Theses and Dissertations.

Nicoloff, A. E. (2018). *Mathematics anxiety and attitudes as predictors of mathematics self-efficacy in developmental mathematics courses* [Doctoral dissertation, Grand Canyon University]. ProQuest Dissertation Publishing.

Ngo, F. J. (2020). High school all over again: The problem of redundant college mathematics. *The Journal of Higher Education*, *91*(2), 222-248.

Ngo, F. J., & Velasquez, D. (2020). Inside the math trap: Chronic math tracking from high school to community college. *Urban Education, 00*(0), 1-29.

NC Community Colleges. (n.d.). *Combined Course Library*. https://www.nccommunitycolleges.edu/academic-programs/combined-course-library

Núñez-Peña, M. I., Guilera, G., & Suárez-Pellicioni, M. (2014). The single-item math anxiety scale: An alternative way of measuring mathematical anxiety. *Journal of Psychoeducational Assessment*, *32*(4), 306-317.

Osterholt, D. A., & Barratt, K. (2012). Ideas for practice: A collaborative look to the classroom. *Journal of Developmental Education*, *36*(2), 22.

Park, T., Woods, C. S., Hu, S., Bertrand Jones, T., & Tandberg, D. (2018). What happens to underprepared first-time-in-college students when developmental education is optional? The case of developmental math and intermediate algebra in the first semester. *The Journal of h\Higher Education*, *89*(3), 318-340.

Paunesku, D., Walton, G. M., Romero, C., Smith, E. N., Yeager, D. S., & Dweck, C. S. (2015). Mind-set interventions are a scalable treatment for academic underachievement. *Psychological science*, *26*(6), 784-793.

Raju, S. R. (2018). *The relationship between mathematics anxiety and academic performance of developmental mathematics students in a community college in Northeastern New Jersey: A case study* [Doctoral dissertation]. ProQuest Dissertation Publishing.

Redl, Timothy A. (2020). Accelerating students successfully through developmental and college-level mathematics and embracing co-requisite models: An 8-week+ 8-week model. *Journal of Education and Social Development, 4*(2), 17-21.

Rhew, E., Piro, J. S., Goolkasian, P., & Cosentino, P. (2018). The effects of a growth mindset on self-efficacy and motivation. *Cogent Education*, *5*(1).

Ricci, M. C. (2021). *Mindsets in the classroom: Building a culture of success and student achievement in schools*. Routledge.

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology*, *19*(6), 551.

Royer, D. W., & Baker, R. D. (2018). Student success in developmental math education: Connecting the content at Ivy Tech Community College. *New Directions for Community Colleges, 2018*(182), 31-38.

Saldaña, J. (2013). The coding manual for qualitative researchers. Thousand Oaks, CA: SAGE Publications.

Samuel, T. S., & Warner, J. (2021). "I can math!": Reducing math anxiety and increasing math self-efficacy using a mindfulness and growth mindset-based intervention in first-year students. *Community College Journal of Research and Practice*, *45*(3), 205-222.

Scott-Clayton, J., Crosta, P. M., & Belfield, C. R. (2014). Improving the targeting of treatment: Evidence from college remediation. *Educational Evaluation and Policy Analysis*, *36*(3), 371-393.

Shively, R. L., & Ryan, C. S. (2013). Longitudinal changes in college math students' implicit theories of intelligence. *Social Psychology of Education*, *16*(2), 241-256.

Smith, L., Martin, W. G., Wan, A., & Dueñas, G. (2017). Students' reactions to reform mathematics pedagogy in a postsecondary remedial mathematics course. *The Mathematics Enthusiast, 14*(1-3), 289.

Smith, L., Martin, W. G., Wan, A., Duenas, G., Shumack, K., & Beziat, T. L. R. (2015). Using reform pedagogy to improve students' application skills in college remedial mathematics courses. *Mathematics and Computer Education, 49*(2).

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research*. Sage publications.

Stavredes, T. (2011). *Effective online teaching: Foundations and strategies for student success*. John Wiley & Sons.

Vandal, B. (2014). Promoting gateway course success: Scaling corequisite academic support. *Complete College America*.

Wang, X., Wang, Y., Wickersham, K., Sun, N., & Chan, H. (2017). Math requirement fulfillment and educational success of community college students: A matter of when. *Community College Review, 45*(2), 99-118.

Wanous, J. P., & Reichers, A. E. (1996). Estimating the reliability of a single-item measure. *Psychological Reports*, *78*(2), 631-634.

Wikoff, R. L., & Buchalter, B. D. (1986). Factor analysis of four Fennema-Sherman Mathematics Attitude Scales. *International Journal of Mathematical Education in Science and Technology*, *17*(6), 703-706.

Yeager, D. S., Hanselman, P., Walton, G. M., Murray, J. S., Crosnoe, R., Muller, C., ... & Dweck, C. S. (2019). A national experiment reveals where a growth mindset improves achievement. *Nature*, *573*, 364-369.

Yeager, D. S., Romero, C., Paunesku, D., Hulleman, C. S., Schneider, B., Hinojosa, C., ... & Dweck, C. S. (2016). Using design thinking to improve psychological interventions: The case of the growth mindset during the transition to high school. *Journal of Educational Psychology*, *108*(3), 374.

Yettick, H., Lloyd, S., Harwin, A., Riemer, A., & Swanson, C. B. (2016). Mindset in the Classroom: A National Study of K-12 Teachers. *Editorial Projects in Education*.

Yin, R. K. (2018). *Case study research and applications* (6th ed.). Sage Publications, Inc.

Zientek, L. R., Yetkiner, Z. E., & Thompson, B. (2010). Characterizing the mathematics anxiety literature using confidence intervals as a literature review mechanism. *The Journal of Educational Research*, *103*(6), 424-438.

APPENDICES

Appendix A: Course Description for the Five Mathematics Pathways

There are five mathematics pathways for entering students to choose from. Each pathway includes a corequisite and a college-level mathematics course. The course students are required to take is determined by their major and degree. The below course descriptions are published by the NC Community College System (NCCCS) and were retrieved from their Course Library (NCCCS, n.d.).

Math Measurement & Literacy Support, MAT 010 - This course provides an opportunity to customize foundational math content specific to Math Measurement & Literacy. Topics include developing the academic habits, learning strategies, social skills, and growth mindset necessary to be successful in mathematics. Upon completion, students should be able to build a stronger foundation for success in Math Measurement & Literacy by obtaining skills through a variety of instructional strategies with emphasis placed on the most essential prerequisite knowledge.

Math Measurement & Literacy, MAT 110 - This course provides an activity-based approach that develops measurement skills and mathematical literacy using technology to solve problems for non-math intensive programs. Topics include unit conversions and estimation within a variety of measurement systems; ratio and proportion; basic geometric concepts; financial literacy; and statistics including measures of central tendency, dispersion, and charting of data. Upon completion, students should be able to demonstrate the use of mathematics and technology to solve practical problems, and to analyze and communicate results.

Algebra/Trigonometry I Support, MAT 021 - This course provides an opportunity to customize foundational math content specific to Algebra and Trigonometry I. Topics include developing the academic habits, learning strategies, social skills, and growth mindset necessary to be successful in mathematics. Upon completion, students should be able to build a stronger foundation for success in Algebra/Trigonometry I by obtaining skills through a variety of instructional strategies with emphasis placed on the most essential prerequisite knowledge.

Algebra/Trigonometry I, MAT 121 - This course provides an integrated approach to technology and the skills required to manipulate, display, and interpret mathematical functions and formulas used in problem solving. Topics include the properties of plane and solid geometry, area and volume, and basic proportion applications; simplification, evaluation, and solving of algebraic equations and inequalities and radical functions; complex numbers; right triangle trigonometry; and systems of equations. Upon completion, students will be able to demonstrate the ability to use mathematics and technology for problem-solving, analyzing and communicating results.

Quantitative Literacy Support, MAT 043 - This course provides an opportunity to customize foundational math content specific to Quantitative Literacy. Topics include developing the academic habits, learning strategies, social skills, and growth mindset necessary to be successful in mathematics. Upon completion, students should be able to build a stronger foundation for success in Quantitative Literacy by obtaining skills through a variety of instructional strategies with emphasis placed on the most essential prerequisite knowledge.

Quantitative Literacy, MAT 143 - This course is designed to engage students in complex and realistic situations involving the mathematical phenomena of quantity, change and relationship, and uncertainty through project- and activity-based assessment. Emphasis is placed on authentic contexts which will introduce the concepts of numeracy, proportional reasoning, dimensional analysis, rates of growth, personal finance, consumer statistics, practical probabilities, and mathematics for citizenship. Upon completion, students should be able to utilize quantitative information as consumers and to make personal, professional, and civic decisions by decoding, interpreting, using, and communicating quantitative information found in modern media and encountered in everyday life.

Statistical Methods I Support, MAT 052 - This course provides an opportunity to customize foundational math content specific to Statistical Methods I. Topics include developing the academic habits, learning strategies, social skills, and growth mindset necessary to be successful in mathematics. Upon completion, students should be able to build a stronger foundation for success in Statistical Methods I by obtaining skills through a variety of instructional strategies with emphasis placed on the most essential prerequisite knowledge.

Statistical Methods I, MAT 152 - This course provides a project-based approach to introductory statistics with an emphasis on using real-world data and statistical literacy. Topics include descriptive statistics, correlation and regression, basic probability, discrete and continuous probability distributions, confidence intervals and hypothesis testing. Upon completion, students should be able to use appropriate technology to describe important characteristics of a data set, draw inferences about a population from sample data, and interpret and communicate results.

Precalculus Algebra Support, MAT 071 - This course provides an opportunity to customize foundational math content specific to Precalculus Algebra. Topics include developing the academic habits, learning strategies, social skills, and growth mindset necessary to be successful in mathematics. Upon completion, students should be able to build a stronger foundation for success in Precalculus Algebra by obtaining skills through a variety of instructional strategies with emphasis placed on the most essential prerequisite knowledge.

Precalculus Algebra, MAT 171 - This course is designed to develop topics which are fundamental to the study of Calculus. Emphasis is placed on solving equations and inequalities, solving systems of equations and inequalities, and analysis of functions (absolute value, radical, polynomial, rational, exponential, and logarithmic) in multiple representations. Upon completion, students should be able to select and use appropriate models and techniques for finding solutions to algebra-related problems with and without technology.

Appendix B: Article I Student Semi-Structured Interview Protocol

1. Tell me about your goals in attending X community college and where you are in your progress.
2. When you signed up for a math course this semester, how did you feel about taking a math course?
    a. What concerns did you have about taking a math course?
    b. What were you excited about?
3. Describe your experiences in the corequisite mathematics course.
4. What do you think about the corequisite course model?
    a. What do you think is effective about the co-requisite course model?
    b. What do you think is ineffective about the co-requisite course model?
    c. If a friend asked if you would recommend they take a corequisite course, what would you say?
5. How would you describe your corequisite instructor's teaching? Can you give me an example.
    a. What do you like about their teaching style?
    b. What do you dislike about their teaching style?
    c. Did they encourage mistakes?
6. What else should I know about your experience taking a corequisite course?

Appendix C: Article I Instructor Semi-Structured Interview Protocol

1. How long have you been teaching developmental mathematics? Specifically, corequisite math courses?
    a. Describe your experience teaching previous developmental courses.
    b. Describe your experience teaching corequisite math courses.
2. When you first began teaching the co-requisite course, did you have any concerns about teaching a course in this format? If so, what were they?
3. How would you describe your teaching style/philosophy?
4. Did your college provide you a curriculum? If so, what do you think about the provided curriculum? If not, how do you develop your lesson plans?
    a. What works well?
    b. What would you change?
5. What do you think about the corequisite course model?
    a. What do you think is effective about the co-requisite course model?
    b. What do you think is ineffective about the co-requisite course model?
6. What else should I know about your experience teaching corequisite course model?

Appendix D: Article I Codebook

Level 1	Level 2	Description	Level 3	Description
Course modalities: Comments about the various course modalities of corequisite mathematics courses.	Asynchronous	Comments about aspects of asynchronous classes, how they felt about asynchronous classes, or their experiences while taking/teaching an asynchronous course.	General	Talked about asynchronous classes in a way that was either vague or didn't fit as an advantage or disadvantage.
			Advantages	Specified an advantage of asynchronous classes.
			Disadvantages or concerns	Specified a disadvantage of asynchronous classes or a concern they had when signing up for the class.
	Comparing the modalities	Comments that compare the three major course modalities: in-person, synchronous, and asynchronous.	General	Comments comparing the various course modalities that was either vague or didn't fit as one of the other codes.
			Recommendation	Provided a recommendation about requiring or highly recommending one course modality over others. Or provided a recommendation specific to a course modality. Or recommended a course modality for themselves as the student.
			Logistical concerns/reasons	Comments about logistical concerns or reasons for why students chose to take one course modality over the others.
			Student learning	Comments about how students might learn easier in one course modality compared to the others.
One versus two instructors: Comments related to whether the gateway pairings have one or two instructors teaching them.	One instructor	Comments related to the impact of having one instructor teach the corequisite and gateway course.		
	Recommending one or two instructors	Comments that give a clear recommendation about having one or two instructors for the corequisite and gateway courses.		

Level 1	Level 2	Description	Level 3	Description
One versus two instructors (cont.)	Two instructors	Comments related to the impact of having two instructors teach the corequisite and gateway course.	Advantages	Specified an advantage of having two instructors teach the corequisite course and the gateway course. OR something that was positive instructors were doing when there were two instructors.
			Disadvantages or concerns	Specified a disadvantage of having two instructors teach the corequisite course and the gateway course.
			Course pacing	Specified how the corequisite and gateway lessons were paced. (i.e., were they reviewing, prepping students for the next day, both, etc.)
			Comparing instructor's teaching Instructor Communication	Comments that compared and contrasted the teaching style of their corequisite and gateway courses. Comments about if and how instructors communicate. Specifically, recommendations about how frequently they should communicate.
Corequisite course layout or structure: Comments about the corequisite course structure and layout. Specifically, the placement of students in corequisite courses, time spent in class, just-in-time instruction, etc.	General or overall	Talked about corequisite classes in a way that was either vague or didn't fit as one of the other categories.		
	Advantages	Specified a general advantage of corequisite courses or having to take corequisite courses.	General	Comments about an advantage that was either vague or didn't fit with another code.
			Student learning	Comments about how students' learning was impacted by the corequisite course structure.
	Disadvantages or concerns	Specified a general disadvantage or concern about corequisite courses or having to take corequisite courses.		
	Comparing to past developmental or math courses	Comments where instructors compared their past developmental math teaching experiences with the current corequisite course model.		

Level 1	Level 2	Description	Level 3	Description
Corequisite course layout or structure (cont.)	"Time"	Comments about the time commitment of the course, which could refer to the logistical aspect of when students attend class but could also refer to the impact of having extra time to work on math.	General	Comments about the time spent in or the layout of the course schedules in a way that was either vague or didn't fit with another code.
			Disadvantages or concerns	Specified a disadvantage of how much time is spent in the corequisite course and the gateway course.
			Student learning	Comments about how students' learning was impacted by having extra time to learn in the corequisite course structure.
			Recommendation	Provided a recommendation about how to restructure the timing of the corequisite course, potentially in relation to the gateway course.
	Class size	The impact of the class size of corequisite courses compared to the gateway. The corequisite courses are usually smaller.		
	Placement	Comments about how students are placed into corequisite mathematics courses.		
	Department layout	Comments about how the department layout impacted corequisite mathematics courses. This includes conversations comparing adjunct to full-time faculty.		
	Transition math	Comments related to Transition math courses in general, how the addition or removal of them to the course offerings could impact students, or the retention of students.	Adding it back to the course offerings	Comments about how Transition math should be added back to the college's course offerings. And why Transition math should be included.
			Other	Discussed Transition math courses in a way that was either vague or didn't fit in one of the other categories.

Level 1	Level 2	Description	Level 3	Description
Corequisite course layout or structure (cont.)	Curricular materials	Comments about college or department provided curriculum, which could include workbooks, pacing guides, etc. This could also include any discussion about the pacing of the curriculum.	General	Comments about any curricular materials in a way that was either vague or didn't fit with another code.
			Course pacing	Comments about the pacing of any of the course pathways, the potential impacts of this pace, and/or if the pacing should be adjusted.
			Provided materials	Comments about if there is a provided list of objectives, pacing guide, curriculum, etc.; if there is flexibility in what materials they use.
Day-to-day in course: Comments about the day-to-day experiences when taking or teaching a corequisite course.	General	Discussed the day-to-day in corequisite courses in a way that was either vague or didn't fit in one of the other categories.		
	Lectures	Comments about how instructors utilized either lecture in their classroom and how instructors work out problems during these lectures. In an online classroom this can look like videos going over notes.		
	Practice (w or w/o group work)	Comments about how and if instructors utilized time for students to work on problems in class. This could include students or instructors discussing group work or student's feelings about group work versus individual work.		
	Additional curriculum or online course system	Comments about the use of additional curriculum resources or online course systems, such as, My Open Math.		
	Corequisite assignments	Comments about the various assignments and work that is completed in corequisite courses.		

Level 1	Level 2	Description	Level 3	Description
Day-to-day in course (cont.)	Materials created for class and/or students	Comments about instructor-created materials for students in their corequisite course, for example, describing the guided notes they make.		
	Communication with students outside of class	Comments about how instructors communicated with students outside of class. For asynchronous students, this includes all communication with the instructor.		
	Use of real-world problems or examples	Comments about an instructors use of real world problems or examples when explaining corequisite concepts.		
	Study skills lessons	Comments about the incorporation of study skills, including, lessons about growth mindset, math anxiety, time management, how to study, etc..		
Teaching style or philosophy: Comments about the teaching style and/or philosophy of corequisite mathematics instructors.	General	Discussed instructor's teaching style/philosophy in a general sense or in a way that didn't fit in one of the other categories.		
	Mistakes or questions	Discussed how instructors approached mistakes and questions in their classroom. In addition, this could also include comments about how instructor's encourage students to ask questions or their attitude surrounding mistakes.		
	Relationships with students	Discussed how instructors build relationships with their students (i.e., by learning about their life outside of school) and the impact of these relationships on students and their learning.		

Level 1	Level 2	Description	Level 3	Description
Recommendations: Recommendations for the corequisite course model or thoughts to share about the implementation process.	All students in corequisites	Recommendation about placing all students into corequisite courses and allowing them the option to opt out if they placed a certain way.		
	Placement	Recommendation about how to place students into corequisite courses.		
	Blackboard layout and permissions	Recommendation about adjusting the Blackboard layout and permissions for the corequisite and gateway courses.		
	Prerequisite corequisite course format	Recommendation from community college C instructors because this is something they have discussed in their department but have not implemented. It would entail a 4-week prerequisite and then a 12-week college level course combination, rather than the standard corequisite course format.		
	Instructor thoughts to share with admin and/or NCCS	Comments about what instructors wished their administrators and the NCCCS office knew.		
	Other	Another unique recommendation.		
Changes their department has implemented: Comments about changes made at the department level that impact the corequisite course model.	Multiple instructors matched with a corequisite instructor	At community college B, they used to have multiple gateway instructors assigned to a single corequisite instructor. Any comments related to this course layout/design should be coded as such.		
	8-week courses	At community college B, they implemented 8-week courses in the fall semester. Any comments related to this new course format should be coded as such.		

Level 1	Level 2	Description	Level 3	Description
Changes their department has implemented (cont.)	Other	Another change(s) their department has made.		
Would they recommend: Comments about if they would recommend corequisite courses to other students (student perspective) or other colleges (instructor perspective)	Student response	Comments about if students would recommend corequisite courses to other students.		
	Instructor response	Comments about if they would recommend corequisite courses to other colleges.		

Appendix E: Student Pre-Course Survey

Q1 Are you 18 or older?

- ○ Yes
- ○ No

Skip To: End of Survey If Are you 18 or older? = No

Display This Question:

If Are you 18 or older? = Yes

Q2 You are being asked to complete a survey for research purposes. The survey is about your mathematical mindset, math anxiety, and math self-efficacy. Completing this survey is voluntary and you can stop at any time by exiting the survey link when completing the survey or by contacting the research team after completing the survey to request your survey data is deleted.

You must be 18 years of age or older, reside in the United States, and currently be taking a precalculus co-requisite mathematics course at Wake Technical Community College to participate in this study.

There are minimal risks associated with your participation in this survey. You will not receive any payment for completing this survey.

If you have any questions about the survey itself, how it is implemented, or survey compensation, please contact Brianna Bentley, blbentle@ncsu.edu, and 704-989-2629 and Erin Krupa, eekrupa@ncsu.edu, and 919-513-2803. Please reference study number 24253 when contacting anyone about this project.

If you have questions about your rights as a participant or are concerned with your treatment throughout the research process, please contact the NC State University IRB Director at IRB-Director@ncsu.edu, 919-515-8754, or fill out this confidential form online.

If you consent to complete this survey, please click the "Yes I consent" option to see the survey.

- ○ Yes I consent
- ○ No I do not consent

Skip To: End of Survey If You are being asked to complete a survey for research purposes. The survey is about your mathemat... = No I do not consent

Q3a Student First Name

_____

Q3b Student Last Name

_____

Q4a Which community college do you currently attend?

- ○ Cape Fear Community College
- ○ Fayetteville Technical Community College
- ○ Forsyth Technical Community College
- ○ Wake Technical Community College

Q4b Which course are you currently taking?

- ○ Math Measurement and Literacy Support
- ○ Algebra/Trigonometry I Support
- ○ Quantitative Literacy Support
- ○ Statistical Methods I Support
- ○ Precalculus Algebra Support

Q4c What is the format of your corequisite math course?

- ○ In person
- ○ Synchronous online
- ○ Hybrid class
- ○ Asynchronous online

Q5 What is the section number for your corequisite math course?

_____

Q6 On a scale from 1 to 10, how math anxious are you?

- ○ 1 (not anxious) (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 (6)
- ○ 7 (7)
- ○ 8 (8)
- ○ 9 (9)
- ○ 10 (very anxious) (10)

Q7 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
You have a certain amount of intelligence and you really can't do much to change it. (1)	○	○	○	○	○	○
Generally I have felt secure about attempting mathematics. (4)	○	○	○	○	○	○
I am sure I could do advanced work in mathematics. (5)	○	○	○	○	○	○
You can learn new things, but you can't really change your basic math intelligence. (6)	○	○	○	○	○	○
I have a lot of self-confidence when it comes to mathematics. (7)	○	○	○	○	○	○
I am sure that I can learn mathematics. (8)	○	○	○	○	○	○

Q8 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
I think I could handle more difficult mathematics. (1)	○	○	○	○	○	○
You have a certain amount of math intelligence and you really can't do much to change it. (2)	○	○	○	○	○	○
Most subjects I can handle O.K., but I have a knack for messing up math. (3)	○	○	○	○	○	○
I can get good grades in mathematics. (4)	○	○	○	○	○	○
Your intelligence is something about you that you can't change very much. (5)	○	○	○	○	○	○
Math has been my worst subject. (6)	○	○	○	○	○	○

Q9 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
I'm no good in math. (1)	○	○	○	○	○	○
I don't think I could do advanced mathematics. (2)	○	○	○	○	○	○
You can learn new things, but you can't really change your basic intelligence. (3)	○	○	○	○	○	○
I'm not the type to do well in math. (4)	○	○	○	○	○	○
For some reason even though I study, math seems unusually hard for me. (5)	○	○	○	○	○	○
Your math intelligence is something about you that you can't change very much. (6)	○	○	○	○	○	○

Q10 If you are interested in being interviewed about your beliefs about mathematics and your experiences in the math classroom, please provide your email address below.

A member of the research team will reach out to you to set up an interview. Interviews will last between 30 - 45 minutes and you will receive a $15 Amazon gift card.

_____

Appendix F: Student Post-Course Survey

Q1 Are you 18 or older?

- ○ Yes
- ○ No

Skip To: End of Survey If Are you 18 or older? = No

Display This Question:

If Are you 18 or older? = Yes

Q2 You are being asked to complete a survey for research purposes. The survey is about your mathematical mindset, math anxiety, and math self-efficacy. Completing this survey is voluntary and you can stop at any time by exiting the survey link when completing the survey or by contacting the research team after completing the survey to request your survey data is deleted.

You must be 18 years of age or older, reside in the United States, and currently be taking a precalculus co-requisite mathematics course at Wake Technical Community College to participate in this study.

There are minimal risks associated with your participation in this survey. You will not receive any payment for completing this survey.

If you have any questions about the survey itself, how it is implemented, or survey compensation, please contact Brianna Bentley, blbentle@ncsu.edu, and 704-989-2629 and Erin Krupa, eekrupa@ncsu.edu, and 919-513-2803. Please reference study number 24253 when contacting anyone about this project.

If you have questions about your rights as a participant or are concerned with your treatment throughout the research process, please contact the NC State University IRB Director at IRB-Director@ncsu.edu, 919-515-8754, or fill out this confidential form online.

If you consent to complete this survey, please click the "Yes I consent" option to see the survey.

- ○ Yes I consent
- ○ No I do not consent

Skip To: End of Survey If You are being asked to complete a survey for research purposes. The survey is about your mathemat... = No I do not consent

Q3a Student First Name

_____

Q3b Student Last Name

_____

Q4a Which community college do you currently attend?

- ○ Cape Fear Community College
- ○ Fayetteville Technical Community College
- ○ Forsyth Technical Community College
- ○ Wake Technical Community College

Q4b Which course are you currently taking?

- ○ Math Measurement and Literacy Support
- ○ Algebra/Trigonometry I Support
- ○ Quantitative Literacy Support
- ○ Statistical Methods I Support
- ○ Precalculus Algebra Support

Q4c What is the format of your corequisite math course?

- ○ In person
- ○ Synchronous online
- ○ Hybrid class
- ○ Asynchronous online

Q5 What is the section number for your corequisite math course?

_____

Q6 On a scale from 1 to 10, how math anxious are you?

- ○ 1 (not anxious) (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 (6)
- ○ 7 (7)
- ○ 8 (8)
- ○ 9 (9)
- ○ 10 (very anxious) (10)

Q7 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
You have a certain amount of intelligence and you really can't do much to change it. (1)	○	○	○	○	○	○
Generally I have felt secure about attempting mathematics. (4)	○	○	○	○	○	○
I am sure I could do advanced work in mathematics. (5)	○	○	○	○	○	○
You can learn new things, but you can't really change your basic math intelligence. (6)	○	○	○	○	○	○
I have a lot of self-confidence when it comes to mathematics. (7)	○	○	○	○	○	○
I am sure that I can learn mathematics. (8)	○	○	○	○	○	○

Q8 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
I think I could handle more difficult mathematics. (1)	○	○	○	○	○	○
You have a certain amount of math intelligence and you really can't do much to change it. (2)	○	○	○	○	○	○
Most subjects I can handle O.K., but I have a knack for messing up math. (3)	○	○	○	○	○	○
I can get good grades in mathematics. (4)	○	○	○	○	○	○
Your intelligence is something about you that you can't change very much. (5)	○	○	○	○	○	○
Math has been my worst subject. (6)	○	○	○	○	○	○

Q9 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
I'm no good in math. (1)	○	○	○	○	○	○
I don't think I could do advanced mathematics. (2)	○	○	○	○	○	○
You can learn new things, but you can't really change your basic intelligence. (3)	○	○	○	○	○	○
I'm not the type to do well in math. (4)	○	○	○	○	○	○
For some reason even though I study, math seems unusually hard for me. (5)	○	○	○	○	○	○
Your math intelligence is something about you that you can't change very much. (6)	○	○	○	○	○	○

Q10 What letter grade do you expect to earn in your math course?

- ○ A
- ○ B
- ○ C
- ○ D
- ○ F

Q11 On a scale from 1 to 10, how satisfied are you with your expected grade?

- ○ 1 (not satisfied)
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10 (very satisfied)

Q12 Briefly explain your reasoning for your answer above.

_____

_____

_____

_____

_____

Q13 If you are interested in being interviewed about your beliefs about mathematics and your experiences in the math classroom, please provide your email address below.

A member of the research team will reach out to you to set up an interview. Interviews will last between 30 - 45 minutes and you will receive a $15 Amazon gift card.

_____

Appendix G: Article II Student Semi-Structured Interview Protocol

1. Tell me about your goals in attending X community college and where you are in your progress.
2. When was the last time you took a math course?
    a. What course was it?
    b. How was your experience in that course?
3. How do you feel about math classes in general?
    a. What positive memories do you have of math classes? Can you give me an example of one?
    b. What negative memories do you have of math classes? Can you give me an example of one?
4. What struggles or success have you experienced in math classes?
5. When you signed up for a math course this semester, how did you feel about taking a math course?
    a. What concerns did you have about taking a math course?
    b. What were you excited about?
6. Describe your experiences in the corequisite mathematics course.
7. What else should I know about how your beliefs about math changed over the course of the semester?

Appendix H: Article II Codebook

Level 1	Description	Level 2	Description	If it influenced a student's...
Student Views About....	Comments made by students about their views about math, how they felt when they signed up for a corequisite, and their past and current experiences in math classrooms.	Math	Comments about their feelings about math. Could include comments about their math anxiety, math self-efficacy, and mindset prior to taking a corequisite course.	
		Signing up for a corequisite	Comments about how they felt when they signed up for a math class, about how they felt prior to the semester starting, or how they felt about the course format.	
		Why their beliefs didn't change	Comments about why the corequisite course did not influence their mindset, math anxiety, or math self-efficacy.	
		Moment of success in math classrooms	Comments about past or present moments when they succeeded in a math classroom or things they need to do as a student to succeed.	
		Moment of struggle in math classrooms	Comments about past or present moments when they struggled in a math classroom or things they do that cause them to struggle.	
Impact of the Corequisite Course	Comments about the impact of the corequisite course on student beliefs.	Time spent in the course	Comments about taking a corequisite course and how the amount of time spent in corequisite courses influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Attendance and participation requirements	Comments about how attendance and/or participation requirements in corequisite courses influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs

Level 1	Description	Level 2	Description	If it influenced a student's...
Impact of the Corequisite Course	Comments about the impact of the corequisite course on student beliefs.	Just-in-time learning	Comments about how the just-in-time learning in corequisite courses influenced students. This code could be used when they are talking about how certain lessons in the corequisite course affected them.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Various modalities	Comments about how the various corequisite courses modalities influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Other course related things	Comments about other additional ways that corequisite courses influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs

Appendix I: Instructor Survey

Q1 Are you 18 or older?

- ○ Yes
- ○ No

Skip To: End of Survey If Are you 18 or older? = No

Display This Question:

If Are you 18 or older? = Yes

Q2 You are being asked to complete a survey for research purposes. The survey is about your teaching practices in the co-requisite mathematics course, mathematical mindset, math anxiety, and math self-efficacy. Completing this survey is voluntary and you can stop at any time by exiting the survey link when completing the survey or by contacting the research team after completing the survey to request your survey data is deleted.

You must be 18 years of age or older, reside in the United States, and currently be teaching a precalculus co-requisite mathematics course at Wake Technical Community College to participate in this study

There are minimal risks associated with your participation in this survey. You will not receive any payment for completing this survey

If you have any questions about the survey itself, how it is implemented, or survey compensation, please contact Brianna Bentley, blbentle@ncsu.edu, and 704-989-2629 and Erin Krupa, eekrupa@ncsu.edu, and 919-513-2803. Please reference study number 24253 when contacting anyone about this project.

If you have questions about your rights as a participant or are concerned with your treatment throughout the research process, please contact the NC State University IRB Director at IRB-Director@ncsu.edu, 919-515-8754, or fill out this confidential form online.

If you consent to complete this survey, please click the “Yes I consent” option to see the survey.

- ○ Yes, I consent
- ○ No, I do not consent

Skip To: End of Survey If You are being asked to complete a survey for research purposes. The survey is about your teaching... = No I do not consent

Q3a Which community college do you teach at?

- ○ Cape Fear Community College
- ○ Fayetteville Technical Community College
- ○ Forsyth Technical Community College
- ○ Wake Technical Community College

Q3b Which course are you currently teaching?

- ○ Math Measurement and Literacy Support
- ○ Algebra/Trigonometry I Support
- ○ Quantitative Literacy Support
- ○ Statistical Methods I Support
- ○ Precalculus Algebra Support

Q4 What is the section number for the corequisite math course you are teaching? If you teach multiple sections, please type them as a comma separated list.

_____

Q5 On a scale from 1 to 10, how math anxious are you?

- ○ 1 (not anxious) (1)
- ○ 2 (2)
- ○ 3 (3)
- ○ 4 (4)
- ○ 5 (5)
- ○ 6 (6)
- ○ 7 (7)
- ○ 8 (8)
- ○ 9 (9)
- ○ 10 (very anxious) (10)

Q6 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
You have a certain amount of intelligence and you really can't do much to change it. (1)	○	○	○	○	○	○
Generally I have felt secure about attempting mathematics. (4)	○	○	○	○	○	○
I am sure I could do advanced work in mathematics. (5)	○	○	○	○	○	○
You can learn new things, but you can't really change your basic math intelligence. (6)	○	○	○	○	○	○
I have a lot of self-confidence when it comes to mathematics. (7)	○	○	○	○	○	○
I am sure that I can learn mathematics. (8)	○	○	○	○	○	○

Q7 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
I think I could handle more difficult mathematics. (1)	○	○	○	○	○	○
You have a certain amount of math intelligence and you really can't do much to change it. (2)	○	○	○	○	○	○
Most subjects I can handle O.K., but I have a knack for messing up math. (3)	○	○	○	○	○	○
I can get good grades in mathematics. (4)	○	○	○	○	○	○
Your intelligence is something about you that you can't change very much. (5)	○	○	○	○	○	○
Math has been my worst subject. (6)	○	○	○	○	○	○

Q8 Please answer the following questions

	Strongly Disagree (1)	Disagree (2)	Slightly Disagree (3)	Slightly Agree (4)	Agree (5)	Strongly Agree (6)
I'm no good in math. (1)	○	○	○	○	○	○
I don't think I could do advanced mathematics. (2)	○	○	○	○	○	○
You can learn new things, but you can't really change your basic intelligence. (3)	○	○	○	○	○	○
I'm not the type to do well in math. (4)	○	○	○	○	○	○
For some reason even though I study, math seems unusually hard for me. (5)	○	○	○	○	○	○
Your math intelligence is something about you that you can't change very much. (6)	○	○	○	○	○	○

Q9 If you are interested in being interviewed about your beliefs about mathematics and your experiences teaching math, please provide your email address below.

A member of the research team will reach out to you to set up an interview. Interviews will last about 45 minutes and you will receive a $15 Amazon gift card.

_____

Appendix J: Article III Student Semi-Structured Interview Protocol

1. Tell me about your goals in attending X community college and where you are in your progress.
2. Describe your experiences in the corequisite mathematics course.
3. What do you think about the corequisite course model?
    a. What do you think is effective about the co-requisite course model?
    b. What do you think is ineffective about the co-requisite course model?
    c. If a friend asked if you would recommend they take a corequisite course, what would you say?
4. How would you describe your corequisite instructor's teaching? Can you give me an example.
    a. What do you like about their teaching style?
    b. What do you dislike about their teaching style?
    c. Did they encourage mistakes?
5. What else should I know about how your instructor influenced your beliefs about math over the course of the semester?

Appendix K: Article III Instructor Semi-Structured Interview Protocol

1. How long have you been teaching developmental mathematics? Specifically, corequisite math courses?
    a. Describe your experience teaching previous developmental courses.
    b. Describe your experience teaching corequisite math courses.
2. How would you describe your teaching style/philosophy?
3. What is your perception of your students' mathematical mindset? Math anxiety? And math self-efficacy?
4. As a teacher, what do you do when your students make a mistake?
5. As a student, how did you feel about math in general?
    a. What positive memories do you have of math classes?
    b. What negative memories do you have of math classes?
    c. What struggles or success have you experienced in math classes?
6. What else should I know about how your students' beliefs about math could have been impacted over the course of the semester?

Appendix L: Article III Codebook

Level 1	Description	Level 2	Description	If it influenced students'...
Student Views About....	Comments made by students about...	Lack of interaction	Comments about how there isn't enough interaction with their instructor in their corequisite course.	
Instructor Views About...	Comments made by instructors about...	Teaching philosophy	Comments about their teaching style and/or philosophy.	
		Something they don't do	Comments in response to a recommendation I made that they do not do in their classroom, do not think would work, and/or why they don't think it would work. For example, saying that lessons on study skills wouldn't be effective with their students.	
		Lack of interaction	Comments about how there isn't enough interaction with students in asynchronous or online synchronous courses to help counteract student's negative beliefs or feelings about math.	
		Lack of time	Comments about how there isn't enough time or not a lot of time to help counteract student's negative beliefs or feelings about math.	
Impact of the Corequisite Instructor	Comments about the impact of corequisite instructors on student beliefs.	Mistakes and questions	Comments about how an instructor approached mistakes and questions and how this influenced students. Also, includes discussions about how instructors attempt to make themselves seem less perfect.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Real-world examples	Comments about how instructors incorporate real world examples into their teaching and how this influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs

Level 1	Description	Level 2	Description	If it influenced students'...
Impact of the Corequisite Instructor	Comments about the impact of corequisite instructors on student beliefs.	Safe and Comfortable Environment	Comments about how instructors try to create a safe and comfortable learning environment for students and how this influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		One-on-one attention	Comments about how instructors provided students with one-on-one attention and how this influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Developing study skills	Comments about how instructors incorporated lessons about study skills, mindset, math anxiety, and/or math self-efficacy into their corequisite course and how this influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Availability outside of class	Comments about how instructors communicated with students and instructors' availability outside of the classroom and how this influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Collaborative Environment	Comments about how a collaborative environment was created by instructors and how this influences students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Instructor's personality or energy	Comments about how instructors' personalities and teaching styles influence students. This includes how they praise and positively reinforce students, comments about their energy in the classroom, or comments about how they interact with their students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs

Level 1	Description	Level 2	Description	If it influenced students'...
Impact of the Corequisite Instructor	Comments about the impact of corequisite instructors on student beliefs.	How they work through problems	Comments about how instructors work through problems (i.e., step by step, at a slower pace, etc.) and how this influences students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs
		Other instructor related things	Comments about other ways that an instructor influenced students.	General/Overall Impact
				Math Anxiety
				Math Self-Efficacy
				Mindset
				Multiple Beliefs