Title

Supporting Student Learning: Unpacking One Institution's Implementation of the Corequisite Model

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Publication Date
2021

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA SAN DIEGO

SAN DIEGO STATE UNIVERSITY

Supporting College Algebra Students’ Learning: Unpacking One Institution's Implementation of the Corequisite Model

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Mathematics and Science Education

by

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2021

The Dissertation of Amelia Stone-Johnstone is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Chair

University of California San Diego

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2021

DEDICATION

To my mother and father – for the example of perseverance, drive, and commitment.

To my siblings – for the unconditional love throughout it all.

To Alanna – for inspiring me.

To Preston – for everything.

EPIGRAPH

“The heights by great men reached and kept were not attained by sudden flight, but they, while their companions slept, were toiling upward in the night.”

- Henry Wadsworth Longfellow

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LIST OF ABBREVIATIONS

GSU	Grizzly State University; Pseudonym for the university where this study was conducted
STEM	Science, Technology, Engineering, and Mathematics
DE	Developmental Education
CSU	California State University
DFW	Drop, Fail, Withdraw

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ACKNOWLEDGEMENTS

I would like to first acknowledge my advisor and chair, Daniel Reinholz. Thank you for being such a great mentor throughout this journey. Thanks for always pushing me to think more critically. I have learned so much from you and from our collaborations.

To my committee, I truly appreciate your time and patience in supporting me in this dissertation process. Mary, you have gone above and beyond what I expected, and I am so grateful that you are as passionate about this topic as I am. I hope that we can continue to collaborate in the future. DQ, thank you for your realism and your constructive criticism. I have enjoyed learning from you throughout these years. My only regret is that we did not get a chance to form a MSED string quartet. There is always tomorrow! Sherice, your positive affirmations meant so much to me. Thank you for helping me construct my interview protocols and supporting me through this journey. Lisa, I am sad that it took forming a dissertation committee for us to finally meet. I enjoyed our conversations and I hope that we will be able to collaborate in the future.

I would like to acknowledge the MSED community. My time in the MSED program has been transformative. Thank you, Joanne Lobato, for helping to enculturate me into the field of mathematics education. Through this program I have grown as a mathematics educator. The MSED students have been such a great support for me as I navigated this program with a newborn. To my peers, you are amazing. I am forever grateful for all the practice talks, social events (when outside was open), and virtual coffee and happy hours. Tina, thanks for keeping me grounded. I hope I was able to support you as much as you have for me. You are amazing and I am so honored to have met and worked with you. Adriana, I enjoyed our writing sessions. I wish you continued success. Kevin, you are going to do amazing things and I am here for all of it!

Isabel and Brinley, thanks for devoting your time in helping me code. Finally, Matt and Naneh, thanks for being such great mentors and role models.

To the CRMSE community, thank you for showing me what interdisciplinary work looks like. Deb Escamilla, words cannot begin to explain how much I appreciate you. Thank you for everything. Melissa Soto, what can I say? You taught me how to be a good mentor. I appreciate your time, support, and prayers during these past two years. Susan, Donna, and Lisa, thank you for being who you are. You always made me (and Alanna) feel so welcomed and loved at CRMSE. Finally, thank you to Judy and Larry Sowder for your generous contribution that helped fund much of the data collection for this study.

To my biological and inherited family, thanks for cheering me on even when you had no clue what I was doing. I promise, no more school after this. Love you all. To my friends, thank you for always being there when I needed you, whether I knew it at the time. Seble, you inspire me. Amelia, you hype me. Jasmine, you challenge me. To my sorors of the Alpha Psi Zeta chapter of Zeta Phi Beta Sorority Incorporated, thank you for being my productive distraction. Through service and sisterly love, I was able to stay grounded in my scholarly pursuits. Thanks for loving and cheering me on throughout this journey.

I would like to acknowledge the prayer warriors in my life. To Pastor and Sister Morrison, I love you. And to the prayer warriors, whoever you are, thank you. Your unrelenting prayers throughout these years has helped guide me through this path while keeping the faith.

Last but not least, I acknowledge Preston and Alanna. Preston, you are my heart and my rock! Alanna, you are my soul.You all have sacrificed just as much as I have during this pursuit, and I am grateful for your love and support through it all. I love you.

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ABSTRACT OF THE DISSERTATION

Supporting College Algebra Students' Learning: Unpacking One Institution's Implementation of the Corequisite Model

by

Amelia Stone-Johnstone

Doctor of Philosophy in Mathematics and Science Education

University of California San Diego, 2021
San Diego State University, 2021

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Introductory mathematics courses at postsecondary institutions simultaneously function as gateways and gatekeepers to degrees and careers in Science, Technology, Engineering, and Mathematics (STEM) for historically minoritized and marginalized students. While these courses provide access to higher education, they also thwart student STEM pathways due to increased time to degree completion, the STEM weed-out culture (Weston et al., 2019), and insufficient academic support structures for students deemed as not college-ready (Koch, 2017). The corequisite model of academic support has been introduced at many institutions nationwide to combat this pressing equity issue. Yet, little is known about students' actual classroom experiences within these courses. But classroom experiences are crucial to student success. Moreover, recognizing that the classroom is part of a larger academic ecosystem, this study examines the intersection of institutional structures (e.g., coordination and placement), classroom

environment, and student experiences in a College Algebra lecture and corequisite course. The goals that guide this investigation are to: (1) Describe an implementation of the corequisite model at a public four-year institution. (2) Examine how opportunities to engage in course content are distributed within corequisite courses. And (3) Understand the impact on the student.

Taking a convergent mixed methods approach, quantitative and qualitative data were collected and analyzed towards addressing these research goals. Using institutional data, student surveys and class reflections, interviews of students and institutional leaders, and classroom observations, I was able to characterize the institutional context and scrutinize the cultural change that occurred at the institution of study, towards adopting corequisites in their College Algebra course. A team of instructors and course coordinator worked together over five iterations to redevelop the College Algebra course. Through the establishment of the core goals of coordination, collaborative learning, and incorporating metacognitive activities, the team of instructors redesigned the College Algebra corequisite to better support their student population. The findings from this study demonstrate the importance of academic scaffolding and community-building in the corequisite course for an enriching learning experience.

Chapter 1: Introduction

Developmental education (DE) is a term that represents programs dedicated to preparing postsecondary students for credit-bearing college coursework (Higbee, 1993; McCabe & Day Jr., 1998). Though its mission is to prepare students, DE has functioned as a gatekeeper to college (Larnell, 2016). Researchers have highlighted various negative effects of DE courses including extended time to degree completion (Boatman & Long, 2018; Bracco, 2019), increased financial burden on students (Boatman & Long, 2018; Brower et al., 2018), and lower student self-efficacy (Hall & Ponton, 2005). These effects have disproportionately affected Black and Latinx students, who tend to be overrepresented in these courses (Larnell, 2016). Many states (e.g., California, Connecticut, Tennessee, Texas) have moved to combat these issues by mandating alternative models of academic support for students identified as needing it (Bracco, 2019; Daugherty et al., 2018; Vandal, 2018); the corequisite model is one model that has been adopted nationwide.

The corequisite model of academic support, also referred to as corequisite remediation (Rutschow & Mayer, 2018; Vandal, 2018) or concurrent learning experience (Arendale, 2010) in other literature, is a support mechanism where students are provided with academic support while enrolled in a credit-bearing college course. There are several variations of this model and many institutions (two-year and four-year alike) have adopted some version of a corequisite model to assist their students who have demonstrated a need for additional academic support. While there exists some literature about the effects of the corequisite model of instruction, there is not enough research on how students respond to the model. This present work aims to do just that; this investigation aims to understand how the corequisite model of academic support affects students' perceptions of self-efficacy and attitudes towards mathematics, and how it prepares them for success in gateway mathematics courses. In addition, this research intends to highlight how these courses can help combat issues of equity in STEM fields, by identifying affordances and limitations of the corequisite model on student outcomes and experiences.

Motivation

With a changing global economy comes a greater desire and need for expertise in the science, technology, engineering, and mathematical (STEM) fields (Fayer et al., 2017; Larnell et al., 2017). However, many college students deviate from STEM pathways after attempting their first sequence of college math courses. There have been numerous studies about the phenomenon of STEM attrition (e.g., Thiry et al., 2019); some of the identified causes of STEM attrition were stereotype threat (Beasley & Fischer, 2012), lower levels of student self-efficacy (Geisinger & Raman, 2013; Wang, 2013), and issues related to self-confidence (Brainard & Carlin, 1998). Another identified factor for STEM attrition was related to the amount of STEM credits attempted and completed within the first years of college (Chen, 2013, 2015). In their study, Chen observed a relationship between the amount of STEM credits taken in the first year and whether a student completed a STEM major. They found that students who took lighter loads were more likely to leave STEM pathways for other non-STEM tracks. One suggested reason for lighter STEM course loads in the first year was student indecision about their major, and their potential interest in non-STEM fields. Another identified reason for having a lighter STEM course load in the first year is that many students were not placed directly into gateway STEM courses and were enrolled in pre-college-level (DE) coursework, and thus ended up taking a longer time to attempt and complete an introductory STEM course.

The latter scenario is what motivates this current investigation. In 2007, nearly half of the incoming students to the California State University (CSU) system schools did not place directly into introductory courses and required some form of remediation in English and/or mathematics (Venezia & Voloch, 2012). Accordingly, placement has been a major issue within the CSU system, and many institutions nationwide. As a result, there has been a push for using multiple measures (high school GPA, standardized tests, placement exams, etc.) to place students in courses that align with their ability (Melguizo & Ngo, 2018; Rutschow & Mayer, 2018). The status quo is to use standardized placement exams, and historically, this has sparked contentious debates around gender and racial equity (Akst & Hirsch, 1991; Melguizo & Ngo, 2018). A prevailing sentiment amongst equity-minded educators is that placement exams based on a single measure (such as standardized exam scores) are inherently biased in nature and perpetuate systemic inequality.

From the 1988 National Education Longitudinal Study, researchers documented that of the students placed in remedial courses 52% of them were from a lower socioeconomic status (SES), and 61% were identified as non-Hispanic Black students. Three decades later, Procknow et al. (2018) found that even though only 27% of the University of Texas at Austin students were classified as being from low SES families, 67% of the students placed in their DE program came from families with lower SES. In addition, they observed that more than 90% of their DE students were students of color. Thus, not much has changed in the thirty years since the National Education Longitudinal Study of 1988. These historically underrepresented communities in postsecondary education continue to be the main consumers of DE (Arendale, 2010). In cases where students were misplaced, Melguizo and Ngo (2018) found that misplacement (or they would call it misalignment) tended to prevail within community colleges with a larger racially minoritized student body.

A Step Towards a Solution

With state legislations across the country moving to greatly reduce or eliminate remedial coursework from state college and universities (e.g., Connecticut Public Act 12-40, California Assembly Bill 705, Texas House Bill 2223, and CSU Executive Order 1110), students who benefit from DE are pushed to take credit-bearing courses for which they are not prepared. Thus, the need to develop a system of academic support for students needing remediation is ever more dire (Procknow et al., 2018; Vandal, 2018). Though these programs can serve as gatekeepers, DE programs in postsecondary institutions also serve as mechanisms for access to higher education and greater social mobility for students, especially for historically minoritized and marginalized students (e.g., Black, Latinx, women, and students from low-income families) in STEM (Henry & Stahl, 2017; Larnell et al., 2017). Ridding colleges and universities of their remedial and DE programs do little to ameliorate the inequities experienced by these students.

Institutions have adopted various support models to support these students, including multiple math pathways, self-paced learning models, flipped classrooms, increasing course contact hours, stretching courses across multiple quarters/semesters, and corequisite remediation (Rutschow & Mayer, 2018; Voigt et al., 2019). Voigt et al. (2019) suggest that such course variations can potentially level the playing field for students who are less prepared and/or did not have access to preparatory content material for gateway courses like Calculus. There are, however, downsides to each of the models. For instance, increasing contact hours for a course adds a financial burden to the student, and stretched courses may increase the time to degree completion (Boatman & Long, 2018; Brower et al., 2018; Voigt et al., 2019). The focus of this manuscript is the corequisite model since many institutions nationwide have adopted this method to prepare their students for general education and gateway courses (Bracco, 2019). A corequisite is an academic support mechanism in which students receive additional scaffolding while enrolled in a college-level course.

According to a 2011 national institutional survey distributed by the Center for the Analysis of Postsecondary Readiness, only 16% of two-year colleges that offered developmental courses presented material using a corequisite model of instruction while 76% reported using the traditional prerequisite sequence model (Rutschow & Mayer, 2018). The prerequisite model consists of a sequence of courses, each focusing on developing skills deemed necessary for success in the subsequent course (Evensky et al., 1997). Many have argued that the prerequisite model does not sufficiently prepare students for gateway courses (Kashyap & Mathew, 2017; Vandal, 2018). Kashyap and Mathew (2017) found that students enrolled in a prerequisite sequence of courses tended to forget the skills they acquired by the time they took the subsequent course. Moreover, there has been a great amount of scholarship supporting alternate models of instruction towards moving away from the traditional prerequisite sequence of DE (Belfield, Jenkins, & Lahr, 2016; Kashyap & Mathew, 2017; Logue et al., 2016).

In many of the past studies around corequisite remediation, the focus has usually been on the positive effect the corequisite model had on students' course grades (Kashyap & Mathew, 2017; Logue et al., 2016), and the faculty response to the model (Bracco, 2019; Daugherty et al., 2018). There is little research around students' experiences while taking a course with a corequisite support, nor whether the model helps solve the equity and access issues for marginalized populations in STEM. In one study that did highlight student experiences, the researchers found that 80% of the respondents to their survey stated a preference towards the corequisite model over a prerequisite model of instruction (Kashyap & Mathew, 2017). Similarly, Fay (2018) reported that students enjoyed the pacing of the corequisite course, and deemed it more manageable than any other courses they had attempted in the past. Thus, there is some indication that students may prefer the corequisite model and that it may be beneficial for student outcomes and experiences, but more work needs to be done in clearly articulating what is going on within the classroom. Furthermore, a focus on the classroom environment and students' experiences within that environment is important given the positive relationship between classroom environment and academic efficacy (Dorman, 2001). A student's academic efficacy has a mediating role on their engagement, performance, and persistence (Bouffard-Bouchard, 1990; Carmichael & Taylor, 2005; Lane et al., 2004; Van Dinther et al., 2011). Therefore, this dissertation aims to document the student experience within the corequisite model to identify strengths and weaknesses in its design.

Research Questions and Goals

Students' learning experiences in DE have not been thoroughly investigated (Larnell, 2016), and to reiterate, the existing research about corequisite remediation tends to focus primarily on student outcomes. As emphasized by Higbee et al. (2005), more work needs to be done in exploring the student experience through the voices of the students themselves. Likewise, there is an insufficient amount of research focusing on what happens within the corequisite classroom and how students engage within that environment. The classroom environment is an essential unit for analysis due to its impact on student identity development and student efficacy beliefs, and by association, student success. Recognizing that the classroom is part of a larger academic ecosystem, this study examines the intersection of institutional structures (e.g., coordination and placement), classroom environment, and student experiences. The findings from this study will add to the literature by explicitly addressing how the corequisite model of academic support functioned at a public four-year Hispanic-Serving

Institution, and how it contributed to student learning and course completion. In addition, this study aims to identify equitable and inclusive practices that have contributed to student success while also highlighting areas that require careful reexamination. The goals that guide this investigation are to:

1. Describe an implementation of the corequisite model at a public four-year institution.
2. Examine how opportunities to engage in course content are distributed within corequisite courses.
3. Understand the impact on the student.

Outlined below are several research questions posed to address each goal. Each goal is re-presented below with its corresponding research questions.

1. Describe an implementation of the corequisite model at a public four-year institution.
    a. What are the goals and beliefs of institutional stakeholders as they pertain to the corequisite model?
    b. How are institutional stakeholders working together to ensure the successful implementation of the model?
    c. What is the nature of the academic support available to students in corequisite courses?
2. Examine how opportunities to engage in course content are distributed within corequisite courses.
    a. How are opportunities to engage in course content distributed in corequisite courses vs. lecture courses?
    b. How do students in corequisite courses engage in their lecture courses?
3. Understand the impact on the student.

a. How are students' interests, beliefs, and attitudes around mathematics and mathematics learning affected through enrollment in the corequisite course?

Organization of the Manuscript

Chapter 2, the Literature Review, provides historical context about DE and about the problems that have emerged around DE, including placement issues and degree completion. To address these criticisms of DE, state mandates and recommendations were put in place, and alternate instructional models were introduced, including the corequisite model. Supporting evidence for the model, criticisms of the model, and design recommendations for the model are then discussed in this chapter. And finally, the three theoretical frameworks (Sociocultural theory, Bandura's sources of self-efficacy, and the Four Frames for systemic change) that guide the research agenda are presented.

Chapter 3, the Methods, outlines the analytic approach for understanding the data. It begins with a presentation of the setting in which data were collected. Following is a presentation of the various data sources. Finally, the analytic methods used to address each research goal are delineated.

Chapters 4, 5, and 6 are all results chapters, one for each research goal. In Chapter 4, the institutional context is presented and the institutional change initiative towards corequisites is described through the lens of the Four Frames for systemic change (Bolman & Deal, 2008; Reinholz & Apkarian, 2018). In Chapter 5, differences in student engagement in the College Algebra lecture and the corequisite support courses are explored. An illustration of the classroom environment in all the observed courses is presented. In addition, patterns in student participation are documented. In Chapter 6, the student experience in these courses is discussed through student voices from surveys, journal reflections, and interviews and focus groups.

In the final chapter, Chapter 7, I discuss the findings from the three results chapters. I then share some contributions to the literature, I provide some implications for practice, I state the limitations of the study, and I highlight future directions for this work.

Chapter 2: Literature Review

As highlighted by Grubb et al. (2011), a large percentage of incoming college freshmen are not prepared for college coursework due to systemic inequality. This systemic problem gives way to students entering college with underdeveloped algebra skills. This is even more prevalent among Black students (Attewell et al., 2006). Many of these students will then need support in passing their gateway courses – these are lower-division college courses that are characterized as foundational, high-enrollment, and high-risk due to the low percentage of students passing with a C or higher (Koch, 2017). Lower-income, first-generation, and racially minoritized students tend to fail these courses at disproportionate rates. Since failure in these courses is correlated to dropping out of college, there has been a great amount of effort devoted to improving teaching and learning in gateway courses, as well as preparing students for success in these courses.

Developmental education (DE) attempts to address this issue by providing students with opportunities to fill educational gaps in preparation for college-level work, including the content in gateway courses. In the literature the term DE tends to be conflated with the term “remedial education” (RE), but Higbee (1993) distinguishes them by highlighting their purposes. While the focus of RE is to fix academic deficiencies, DE goes beyond remediation with a focus on cultivating skills. When discussing DE in this manuscript it will be in reference to a program that embodies Higbee's (1993) definition, where students are able to fill educational gaps while developing metacognitive skills that are needed for them to learn old and new concepts. Developing metacognitive skills is essential for learning, since deficiencies in these skills can lead to biases in the assessment of one’s ability (self-efficacy), which can have a negative impact on mathematical performance (Zimmerman et al., 2011).

In this chapter the historical context for DE is outlined, and a depiction of its effect on marginalized communities is depicted. Particularly, DE has been a vehicle for greater access to higher education for communities with less social capital (low income and marginalized populations). Following, some general criticisms of DE are identified and examples of how state legislators have intervened to address these issues are presented. In the subsequent section, the corequisite model of academic support is introduced. The corequisite model has been adopted by many institutions in response to a call for change from the traditional prerequisite DE model. A discussion of the impact of the classroom structure on the student in terms of their attitudes towards mathematics and their sense of self-efficacy follows. The chapter concludes with a presentation of the theoretical frameworks that guide the research agenda.

History of Developmental Education

DE has been around since the 18th century, a time when most postsecondary institutions offered DE courses (Arendale, 2010). DE was initially administered in the form of tutoring for wealthy white male students, as they made up the population of consumers of postsecondary education at that time (Arendale, 2016). With the emergence of precollegiate preparatory academies, and later, the improved quality of the K-12 education system, wealthy white communities began to gain more access to a better educational experience prior to enrolling in college. As a result, by the 20th century developmental programs were not a necessity for wealthy white men, and colleges and universities began to make less revenue from these programs. Institutional leaders at colleges and universities recognized that by expanding admission to women and students of color, they would be able to increase their revenue streams. They accomplished this mission by creating new DE programs for this new population of students who did not have prior access to college preparatory work. These DE programs were welcomed by institutions looking to diversify and increase access to higher education without actually including students and/or preparing students with underdeveloped skills for credit-bearing college courses (Henry & Stahl, 2017), nor providing them with adequate support to succeed academically (Arendale, 2016).

A stigma began to grow around DE since the students who tended to need DE programs were more often from communities with under-resourced K-12 education programs. These students included populations of lower-income, immigrant, and/or racially minoritized status. According to the 1988 National Education Longitudinal Study, 52% of low-income and 61% of Non-Hispanic Black students participated in DE (Attewell et al., 2006). This is consistent with Procknow, Deithoff, and Herd's (2018) observation that during the Fall of 2016, 67% of developmental students beginning at the University of Texas at Austin came from lower-income families. This is noteworthy considering that only 27% of the students at this institution were classified as low-income. In addition, they noticed that 90% of the developmental students at the institution were students of color.

This fact is very important as it shows that DE primarily serves and impacts students from historically marginalized and minoritized communities. Arendale (2010) suggested, “developmental courses are often a key ingredient in providing access and success for historically underrepresented students” (p. 19). As college admissions standards increased and availability of DE courses diminished, community colleges became the main source for providing access and addressing academic unpreparedness (Arendale, 2010). There is an argument for and even an expectation by some that students needing DE be redirected to two-year institutions to acquire the necessary skills that they lack. In 2010, 68% of community college students enrolled in at least one DE course (Daugherty et al., 2018). Though DE can provide access to students who would normally be weeded out by admissions standards, for many students DE programs serve as a gatekeeper to higher academic endeavors (Henry & Stahl, 2017; Larnell et al., 2017).

Problems with DE

DE has experienced a lot of criticism. For one, there isn't uniformity in placement decisions across contexts which may lead to improper placement of students (Rutschow & Mayer, 2018). Once students are placed in DE courses, another criticism is that these students are not learning and developing the skills they need to be successful in subsequent courses (Scott-Clayton & Rodriguez, 2015). A third criticism is the extended time it takes to take a credit-bearing course and ultimately complete a degree (Boatman & Long, 2018). A fourth criticism is about the type of instructors that tend to serve DE courses; adjunct faculty are often the primary instructors of these courses. And finally, DE carries a stigma which can affect how relevant stakeholders approach these courses.

How Are They Placed?

The first criticism of DE is not really a criticism of DE itself but rather the system in which it operates. That is, there is concern about the placement mechanisms that allow for students to be placed into developmental courses unnecessarily (Rutschow & Mayer, 2018). This is due in part to the common practice of using placement exams to determine students' mathematical ability. Many studies have questioned the validity of this practice of using standardized tests to place students. As a result of the collective complaint, institutions have begun adopting multiple measures for placement such as high school GPA and previous coursework. It is still yet to be determined what measures are more appropriate in placing students but relying on multiple measures is a start to addressing course placement issues.

From 2011 to 2016 there was a great increase (from 27% to 57%) in the adoption of multiple measures for placing students enrolled in public two-year institutions nationwide (Rutschow & Mayer, 2018). As of 2018, all California community colleges use multiple measures to place their students (Park et al., 2019). This is important because appropriate placement of students increases the chances for students to progress through course sequences in a timely manner (Fong et al., 2015). This implies that DE will serve students who genuinely need the level of support offered in developmental courses.

Even with these changes in placement, Melguizo and Ngo (2020) have reported another problem with placement which they call inter-sector math misalignment (ISMM). ISMM is a construct that explains the phenomena of high school students graduating as "college-ready" but placing into remedial math courses upon entering postsecondary education. This misplacement issue is not merely a problem of using a singular measure to place students, but rather a consequence of nonequivalent definitions of college readiness between high school and postsecondary institutions. To test how prevalent the issue of ISMM was, Melguizo and research team (Melguizo & Ngo, 2018, 2020; Park et al., 2019) collected data from 33,246 students who graduated from a large urban school district and subsequently enrolled in a local community college district. To measure college readiness, they used several indicators such as cumulative high school GPA, an inventory of high school math courses taken (including grade received), and scores on a state standardized test (EAP) which is administered to 11^{th} graders to measure whether they are academically prepared for college coursework. From this study they found various instances of ISMM, where students were placed in DE though their scholastic record may have indicated that they were "college-ready". This included about 23% of students with a high school GPA of over 3.7, 36% of students who took precalculus in high school, 15% of students who took calculus in high school, and 25% of students who were considered "college-ready" based on their scores on the EAP being placed in a DE course.

Are They Learning?

A second criticism of DE is on the content the students are learning. Studies have shown that enrollment in developmental math does not have a statistically significant effect on success (completion with C or higher) in credit-bearing math courses (Boatman & Long, 2018). Scott-Clayton and Rodriguez (2015) suggested that developmental courses do not develop students' skills. Various studies have shown that the skills learned in such classes are procedural skills, as opposed to conceptual knowledge (Larnell, 2016; Quarles & Davis, 2017). While procedural skills allow for better grades in current DE courses, they do not give way to success in subsequent credit-bearing courses. Obtaining these skills does not necessarily imply "college readiness", nor is it associated with degree/certificate completion (Fong et al., 2015; Quarles & Davis, 2017). In addition, many DE students are enrolled in courses that they had previously taken in high school. Sonnert and Sadler (2014) showed that these students tend to employ similar methods that they did in high school. Thus, the potential for conceptual growth may be stymied due to a sense of disheartenment for having to repeat the course.

Are They Completing the Degree?

As discussed earlier, there are a variety of ways that students are placed into DE courses. Depending on their placement, they can end up taking two or more DE courses as opposed to a single course. For clarification, DE is not a single course but can consist of a multi-semester sequence of courses (Dunigan et al., 2019; Kashyap & Mathew, 2017). This prerequisite model of academic support is expensive to both the student and the university; the student pays more tuition for more classes and the university spends more money to offer additional courses and resources to support them. Interestingly, research has shown that students needing a single DE course are less likely to complete a college degree (Boatman & Long, 2018; Scott-Clayton & Rodriguez, 2015). This finding is consistent with Fong, Melguizo, and Prather's (2015) finding that students who enter the lower levels of DE (needing more courses) are attempting and passing at higher rates than those who entered at higher levels of DE (needing a single course). This finding suggests that students needing a single DE course may actually be worse off than those needing an extensive sequence of DE courses. Still with such findings, Black students (when compared to white students) are still estimated to be less likely to successfully progress through the DE sequence (Fong et al., 2015). However, Fong et al. (2015) concluded that women (on average) were more likely to progress through the DE sequence.

Who Teaches DE Students?

Students from historically marginalized groups tend to be overrepresented in DE courses (Larnell, 2016). For this fact alone, it is important to consider who is servicing this population of students and what mechanisms are in place for equitable classroom instruction. Typically, adjunct faculty, as opposed to full-time faculty, are more likely to teach low levels of DE courses and are less likely to have sufficient resources to teach these courses outside of the traditional lecture-based approaches (Kosiewicz et al., 2016). Active learning, defined as a learning environment where students are meaningfully and actively engaged in the social construction of their knowledge within the classroom, is often positioned as a more effective approach for student learning (Freeman et al., 2014; Lombardi et al., 2021; Prince, 2004). Whether it is the best instructional approach, or at least better than lecturing, is debated within the research community (Andrews et al., 2011; Hora, 2014; Prince, 2004). Even with the debate around active learning, there is still agreement that lecturing is not the best approach to instruction. Thus, there is a need for more resources and professional development for faculty teaching these courses.

In addition to just understanding the type of instructors that are inclined to teach DE courses, various researchers have attempted to analyze the effect of the type of instructor on students' academic performance (Burgess & Samuels, 1999; Fong et al., 2015). One finding showed that the type of instructor (adjunct vs. full-time) in a student's first class may affect their outcomes in their subsequent class (Burgess & Samuels, 1999). The researchers found that students who first took a course with an adjunct instructor and then a full-time instructor were more likely to be underprepared for the second class, when compared to those whose instructor order was adjunct/adjunct, full-time/adjunct, or full-time/full-time. These students were less likely to complete the course and were less likely to pass with a C or better. It is worth noting that in this same study, the researchers found that students received higher course grades when they took courses in the adjunct/adjunct order. Their interpretation of this finding was that adjunct faculty tend to be easier graders. However Fong et al.'s (2015) finding, that students taking their first DE course with an adjunct faculty member tend not to do well in their second DE course regardless of instructor, seems to conflict with this previous finding. One takeaway from these research findings is that there needs to be more consideration in appointing faculty to teach DE courses.

The Stigma

A final criticism of DE is the stigma that surrounds it. Full-time instructors are less likely to teach these courses due to an institution's push to schedule them in higher-level courses (Adams, 2019), or maybe even due to a lack of interest in teaching these courses. This may be the reason why a lot of DE courses are taught primarily by adjunct faculty. An instructor's academic ability, and the institution's academic rigor comes into question when DE is taken up (Shields, 2005). Students may also feel the burden of the DE stigma. It was mentioned previously that a stigma started to grow around DE once the population needing DE began to change. No longer are DE students wealthy white men, now they include lower-income, immigrant, and racially minoritized students. Coupled with the stigma of DE being for students with insufficient high school preparation, the stigma around the community of DE constituents (being of low social status due to poverty, immigration, and minority statuses) amplified the overall negative perception of DE. Aside from these elements, there are other contributors to the DE stigma including mandatory enrollment in DE, being grouped in a cohort of students identified as needing remediation, terms like "at-risk," and policy debates on whether students needing academic support should be allowed to enroll in postsecondary institutions (Arendale, 2010).

All in all, remedial courses are diversionary in that their main role is to sort students according to ability (Scott-Clayton & Rodriguez, 2015). DE courses ensure that both "college-ready" and non-"college-ready" students are getting the most out of the courses they are taking. However, institutional factors such as size and student demographics tend to color student success in these programs. For instance, previous research has suggested that the larger the institution the lower the student success rate in DE (Fong et al., 2015). Meanwhile, higher SES serving institutions tend to have better success rates. Therefore, equity and access continue to be a prevailing problem with DE. While the Civil Rights Act, the Higher Education Acts, and a great amount of federal and state funds have expanded access to postsecondary education, there has not been any significant amount of achievement gains (Koch, 2017). In the next section, legislative moves that attempt to address problems linked to student success in DE are highlighted.

State Policies to Address the Problems

Several states' legislative bodies have put forth policies to address many of the issues that have been linked to DE at postsecondary institutions, such as student retention and extended time-to-degree. In 2017, California legislators established Assembly Bill 705 which mandates community colleges "to maximize the probability that the student will enter and complete transfer-level coursework in English and mathematics within a one-year timeframe" (*AB-705 Seymour-Campbell Student Success Act of 2012: Matriculation: Assessment*, 2017). In addition, this bill requires that students be placed into courses using multiple measures such as high school coursework and grades, and it prohibits the requirement for remedial coursework that would lengthen a student's time-to-degree unless placement data indicates that a student will not succeed in transfer-level (credit-bearing) coursework. Around the same time, the California State University (CSU) system issued a similar mandate (EO-1110) with the purpose of moving away from a prerequisite structure of DE. In particular, EO-1110 mandates that students be placed directly into credit-bearing courses, and those needing academic support be offered support in the form of supplemental, corequisite, or stretched instruction (*Assessment of Academic Preparation and Placement in First-Year General Education Written Communication and Mathematics/Quantitative Reasoning Courses: Executive Order (EO) 1110*, 2017).

Texas governor Greg Abbott signed into law in 2017 Texas House Bill 2223. Like the California legislations, this bill moved to eliminate the prerequisite structure of DE by providing students with an alternate method to get students "college-ready". This bill imposed a corequisite structure to DE by mandating that all postsecondary institutions (except technical schools and certificate programs) provide some form of supplemental academic support while students are concurrently enrolled in a corresponding college-level course (*FAQs: HS2223 Implementation*, n.d.). In 2014, Connecticut's government passed the Public Act 12-40 which also took a step away from the traditional prerequisite structure of DE to one where underprepared students are offered a one-semester intensive college readiness course (Vandal, 2018). The goal was for students to enroll in a college-level course by the end of their first year. The legislation provides students who need additional support with an option to enroll in a support course while enrolled in a college-level course.

These state policies have the potential to affect student academic outcomes and college experiences. As it is to be expected, the enactments of these policies are not without criticism. The research on the effects of these policies is preliminary and will be discussed in greater detail in the following section. One preliminary finding from Brower et al. (2018) suggested that the policies and programs created from the 2013 Florida Senate Bill 1720 have the potential to negatively impact "at-risk" students. The senate bill gave students the freedom to choose the type of DE they wanted to enroll in or to opt-out altogether (*SB 1720 - The Florida Senate*, 2013). This bill also imposed a requirement for DE courses to be completely revamped and taught with new instructional material through modularized instruction (students work through modules to learn material that they had missed) or corequisite instruction (Brower et al., 2018).

The Florida legislation provided students with the option to take a placement exam for assignment into a DE course, with the students placed into DE courses having the choice to opt-out of DE courses altogether. After this DE reform, Brower et al. (2018) noticed a decrease in educational scaffolding for at-risk students. Scaffolding in course sequencing, where advisers worked with students to design tailored course pathways that aligned with students' interests, diminished significantly due to confusion around the policy. Students began opting out of courses that they needed due to financial burden or due to the lack of ability to self-assess their needs. Thus, state legislation can have unintended consequences that can hamper students' ability to succeed. With that understanding, this present study aims to identify the affordances and limitations of the corequisite model of academic support. The focus of this study is on the corequisite model because many institutions nationwide have chosen to adopt this model in response to calls for change, and the institution studied in this research project specifically chose this model to support their students.

The Corequisite Model

There have been various course models developed to address the issues around student retention and completion. Some models for developmental courses include multiple math pathways, self-paced learning models, flipped classrooms, and corequisite remediation (Rutschow & Mayer, 2018). Multiple math pathways refer to course sequencing designed to provide the relevant math skills for degree requirements. For example, if a student is pursuing a pre-medical degree, they need not take a standard Calculus course but rather a domain-specific Calculus course which would equip them with the relevant skills needed to be successful in their biological science classes. Self-paced learning models refer to modules designed for students to work through the course content at their own pace (Rutschow & Mayer, 2018). This model is a form of mastery learning where students receive feedback immediately as they work through the material. Flipped classrooms refer to courses where students receive course content outside of the classroom and spend time within the classroom working on relevant activities. This method of instruction has become increasingly more popular given the push for active learning activities within the classroom and also the greater access and availability of internet resources (Herreid & Schiller, 2013).

Corequisite remediation is a broad term to describe a model where students take a college-level course while simultaneously enrolled in a developmental support course or some form of structured support mechanism (Arendale, 2010; Rutschow & Mayer, 2018; Vandal, 2018). For example, a corequisite to a College Algebra course is a separate workshop where students can ask questions, get just-in-time remediation, and get more practice with course materials. In design, the corequisite model is a replacement for the traditional prerequisite structure of math sequencing by providing students with just-in-time remediation (Vandal, 2018). As many institutions have moved to adopt this model, it has taken on a variety of flavors. For instance, the corequisite model can be presented in a single semester format or in a one year format (Vandal, 2018). Regardless of the presentation the unifying theme behind the corequisite structure is to provide students with academic support without the burden of significantly lengthening the time it takes to satisfy degree requirements. Details about some of the different representations of the corequisite model are elaborated in the following section.

Flavors of the Corequisite Model

The corequisite model can be implemented in various ways. One variation among the corequisite model is in terms of general enrollment. At some institutions enrollment in corequisite support courses is not required (e.g., Florida senate bill), where students determine whether they would like/need additional interaction with course material (Arendale, 2010). At other institutions students are placed and required to attend corequisite courses based on institutional placement standards.

A second variation among the corequisite model is in terms of course coordination. The corequisite model can be managed like a coordinated program where the instructor of the main/parent credit-bearing course either also teaches the corequisite support course or is involved in structuring the course materials (Arendale, 2010). In such approaches, there is direct alignment between the course material and activities in the parent course and the support course. The opposite can also occur; the corequisite model can also function in a less coordinated manner where there is not much alignment between the parent and support course. In fact, this was one main complaint among CSU faculty after the first year of implementing EO-1110 (Bracco, 2019). In response to a lack of coordination, CSU faculty have pushed for more professional development around coordination and for more consistency across instructors and between co-courses (support) and parent courses. In addition, the faculty have emphasized the need for professional development to be incorporated into adjunct faculty's employment contracts since these are the people who are more likely to teach courses with a corequisite support; contractual obligations can facilitate instructor support for the model.

Another definition of course coordination used in the literature was in terms of the structure of the class itself. In one instance, corequisite remediation can be offered using a cohort model where underprepared students are segregated and offered separate courses than students who are deemed "college-ready" (Richardson & Dorsey, 2019). In such a program, the academic support is infused with the parent course in a coordinated manner where all students are dually enrolled (Arendale, 2010). In other words, students needing academic support will take a unique version of the course, with an additional unit(s), where the support material is blended with course content. Many Texas community colleges have used this paired model where DE students (students identified as not "college-ready") receive a specialized version of the parent course

(Daugherty et al., 2018). Alternatively, corequisite remediation can be offered in a comingled setting where underprepared students take the same credit-bearing classes with “college-ready” students while receiving additional support outside the parent course.

A third variation among the corequisite structure is in terms of the length of the academic support. Academic support can range from as short as a semester to as long as an academic year (Vandal, 2018). Within the semester-long approach, the corequisite model can be structured by adding an additional unit to a college-level course thus increasing the meeting time for a class (Daugherty et al., 2018; Vandal, 2018). Another common variant for the corequisite model, especially among the CSUs, is the mandatory tutoring/lab/workshop structure where students receive customized support outside the parent course. What happens in the mandatory lab can also vary, from supplemental instruction by the same or different instructor as the parent course, to technology-mediated support models (like the self-paced learning models described earlier). A final example of the semester-long approach is the sequenced approach where students take an intensive developmental course for the first five weeks (length may vary by institution) and then an intensive gateway course for the remainder of the semester. An example of a year-long approach is the “stretched” approach where a gateway course is extended from a single semester to a full year. In these instances, course content is intentionally aligned with the core developmental skills needed for success in the gateway course.

Support for the Corequisite Model

Numerous state legislations have backed the use of corequisite models by issuing mandates (e.g., California, Texas), recommendations (e.g., Indiana), or financial incentives (e.g., Colorado). The mandates have been discussed in a previous section. As for recommendations, the Indiana Commission for Higher Education (ICHE) (a state government entity) issued a resolution that posited the corequisite model as best practice (Vandal, 2018). In accordance, the state's community college system has widely adopted the model to complement their remedial courses with corequisite support courses. However, these institutions' decision to implement corequisites may not only be a result of the recommendation by the ICHE. Indiana has an outcomes-based model for financial support for the state's public institutions. This means that there is an implicit financial incentive for postsecondary institutions to implement such an academic reform. In the case of financial incentives, the Colorado House Bill 12-1155 poses an explicit financial incentive for the adoption of corequisites. They have offered funding for postsecondary institutions to provide corequisite courses for students needing academic support.

Support for the corequisite model has also stemmed from findings from research studies. In one study Logue, Watanabe-rose, and Douglas (2016), showed that students who completed a course with a workshop performed better than students who did not. Their findings did not differ by race, thus indicating that at the very least corequisite remediation did not worsen racial inequities in mathematics. In other words, their findings may suggest that all students are benefiting from the corequisite structure.

In a second study, Kashyap and Mathew (2017), found that 80% of the 155 freshmen students surveyed stated a preference towards the corequisite model. These students were placed in three different quantitative reasoning courses; 70 were placed in a standard three-credit course, and the remaining 85 were randomly placed in either a one-credit prerequisite course followed by a standard three-credit during the following semester, or a standard three-credit course with a one-credit corequisite support course. All courses were taught by full-time tenured/tenure-track faculty using a common syllabus, instructional materials, and assessments. They found that corequisite students outperformed students in all other models. These students received higher course grades (49% of corequisite students received a B or higher compared to 43% and 26% of students in the standard course and standard course with prerequisite course respectively), and a greater percentage of them met the benchmark for learning outcomes relative to prerequisite students. In a final study, Logue (2014) positioned college-level courses with workshops (e.g., corequisite courses) as “more efficient investments” than the traditional prerequisite sequencing of remedial courses. They arrived at this conclusion after recognizing that students enrolled in a workshop support were more successful than those who did not.

Critique of the Corequisite Model

The corequisite model represents a wide-swath of programs aimed at providing assistance while students are enrolled in credit-bearing courses (Vandal, 2018). This model is used to counter retention and completion problems that have been prevalent in the traditional prerequisite system. As Childers et al. (2021) concluded, student attrition may persist even with the corequisite model. And with such a diversity of possibilities in the mode of implementation, it is important that there is proper education among all stakeholders at the institution about the purpose and planned execution of their intended corequisite program. In fact, this was a main criticism identified by community college faculty in Texas (Daugherty et al., 2018) and CSU faculty in California after the first year of implementing corequisites (Bracco, 2019). With the top-down approach (legislative mandate), they complained about not having enough time to adequately inform and train faculty on the model, nor time to iteratively develop appropriate courses. Without such consideration, there was not a lot of faculty support due to skepticism about the effects of the corequisite model on students’ learning and success in subsequent math courses. In fact, these were some of the challenges Wakefield (2020) reflected on when talking about his experience as a department chair implementing corequisites at his 12,000 student four-year institution.

In implementing the corequisite model, there have been numerous institutional obstacles; this a second criticism of the corequisite model. For one, coordinating with various institutional players in scheduling corequisite courses can be difficult. The course enrollment manager system at CSUs became an added burden due to the difficulty in estimating the amount of courses the university should offer, as well as the amount of support courses that would be needed (Bracco, 2019). Wakefield (2020) shared that his institution experienced technical issues related to implementing the corequisite model. The web registration portal was an obstacle when trying to link corequisite courses to the students who needed them.

Another institutional obstacle is the increase in contact hours. Most flavors of the corequisite model entail an increase in units, which means an added financial burden on the students. The stretched model of corequisites poses the problem of increasing the time-to-degree since a semester course will have been converted to a year-long course. From an equity standpoint, these added costs disproportionately affect low income, first-generation, and/or minority students. These are the students who tend to need corequisite remediation the most, and they may not be able to afford the additional financial burden of taking added units or spending additional semesters at the institution.

Another financial obstacle as a result of the corequisite model, is an increase of cost to the institution (Belfield et al., 2016). Specifically, with more effective courses comes more retention of students. As more students are retained, then more courses need to be offered. Consequently, the institution will need to invest in more human resources; this cost includes hiring more faculty and also training them in the relevant instructional model. Wakefield (2020) discussed that his institution received grant funding to offer professional development for the adjunct faculty teaching these courses. From a distance, it appears that the cost per student in the corequisite model may be more than in the traditional prerequisite model. At the very least, this added cost of transitioning to the corequisite model includes professional development and course redevelopment, two of the necessary factors expressed by many institutional leaders (including CSU faculty) for proper implementation of the model (Bracco, 2019; Wakefield, 2020).

Designing Corequisites

A major benefit of corequisite support courses is the ability to integrate remedial material with college-level content (Kashyap & Mathew, 2017). The design of the model encourages the linking of DE tasks with relevant college-level material for students to get just-in-time support to make deeper connections. With the elimination of formal DE courses, the corequisite model seems to provide access to higher education for populations of students who would not have had the opportunity otherwise. Since there is no uniformity in the implementation, it is essential to highlight some best practices in designing corequisite support courses. From their research in the area, Daugherty et al. (2018) and Procknow et al. (2018) described some essential features and strategies for designing a successful corequisite program. Some of these will be elaborated below.

The main criticism of corequisites identified in the previous section was the lack of proper education among stakeholders. This problem contributes to the issue of faculty support for the change initiative. The University of Texas at Austin (UTA) circumvented this problem by ensuring that all faculty were trained by faculty members of the Texas Success Initiative (TSI) (Procknow et al., 2018). TSI is a program at that university that focuses exclusively on piloting and scaling the corequisite model of academic support. Through this training, faculty are better able to communicate concerns, negotiate terms of implementation, and they are provided evidence of the effectiveness of the model (Daugherty et al., 2018).

As Wakefield (2020) discussed, getting support from institutional stakeholders including, "upper administration, math faculty, math adjuncts, academic advisors, and academic support services" (p. 665) is essential. Counselors, administrators, and even information technology professionals are stakeholders. They too are important for the successful implementation of the model. The institutional obstacles, such as scheduling, can be minimized through clear communication of the needs and purposes of the model as well as by choosing a flavor that complements the structure of the institution (e.g., considering semester system vs. quarter system) (Daugherty et al., 2018).

Finally, students are also stakeholders, and their voices are just as important for the success of the model. UTA uses multiple measures to place students into math courses. Students then receive advising about their options of course models. Those students who are near the cut-off for corequisite support are interviewed to determine their level of mathematical confidence and their motivation. These data are then used to determine appropriate placement (Procknow et al., 2018). Thus, UTA does not rely solely on academic scores to place students, they also rely on student agency through dialog to determine the right fit for the student.

What Happens in the Classroom Matters

Moving away from the prerequisite model and offering course variations, such as the corequisite model, have been found to level the academic playing field for students (Voigt et al., 2019). These changes allow for more opportunities for active learning, where students can engage with course material in a meaningful way. What happens in the classroom matters because of the positive relationship between degree completion and student engagement in active and collaborative learning (Wang et al., 2017). Therefore, in studying the corequisite model, it is important to understand the students, their behavior in the courses, their attitudes towards mathematics, and their beliefs about their own ability.

Characteristics of a Successful Student

The composition of universities has changed significantly from its rich and wealthy white past to its multicultural present. When we think of a successful student, we often think of institutional factors such as Advanced Placement, scholarships, high ACT/SAT, etc. Lundberg et al. (2018) challenged these conceptions of the successful student in their case study of students with underdeveloped mathematical skills enrolled in remedial education at a tribal college. In their investigation, they recognized that successful students were not determined by placement scores but rather by practices taken up to progress through their programs. These practices were not unique to remedial students and were common among “college-ready” students.

Lundberg et al. (2018) identified metacognitive practices as an essential characteristic of a successful student. Metacognition is defined as the ability to observe one’s own level of understanding and determine whether it is adequate. It is composed of *knowledge of cognition* and *regulation of cognition* (Schraw et al., 2006). *Knowledge of cognition* is defined as what we know about our cognition while *regulation of cognition* includes planning, monitoring, and evaluation within cognitive processing.

The students in Lundberg et al.'s (2018) study had many of these traits, and they frequently talked of specific math content that they needed for their degree as opposed to explicit classes. These students were aware and concrete about the things they needed to do to succeed. They were aware of what they knew and their educational gaps, and they were intentional about the units they planned to take. Finally, they routinely identified their successes and leveraged them to approach the next challenge. These are characteristics that are associated with experts, who tend to be more self-regulated, and tend to participate in global planning before they attempt a task (Schraw et al., 2006). Therefore, students needing additional academic support should not be written off as academically deficient, but rather provided opportunities to develop metacognitive abilities that can aid them in problem solving (Ryals et al., 2020; Schneider & Artelt, 2010).

Corequisite support courses are great places to foster these types of skill development. This was one takeaway from the pilot of the corequisite model at the institution studied by Allen et al. (2018). They recommended the incorporation of metacognitive activities in corequisite courses. In fact, they suggested that metacognitive activities be "front-loaded" at the start of the course in order to motivate and sustain metacognitive behaviors throughout the semester. They added, "students [need] to see the immediate connection and experience success in their other course" (p 37). Thus, in designing corequisite courses, it is important to seamlessly entwine metacognitive activity within course content such that students see the connection and the benefit of the work in which they are engaged.

Students' Attitudes Toward Mathematics

A student's attitude towards mathematics is defined by the emotions they have regarding mathematics, their beliefs about mathematics, and their behavioral response in mathematical settings (Zan & Di Martino, 2007). Many researchers study students' attitudes because this construct is widely recognized as an important factor for learning and mathematical achievement (Julian, 2017; Majeed et al., 2013; Moenikia & Zahed-Babelan, 2010; Neale, 1969).

Being placed in a developmental course, or needing a corequisite support course, can be stigmatizing. This is especially true for those students needing to repeat high school coursework. Daniel Teague's position that, *for students to learn calculus, they must want to learn calculus* (Bressoud, 2016), is a common stance held by instructors who tend to disregard the impact of social and personal factors on students' attitudes towards a subject. Thankfully, Teague's stance is not a universally held position by all educators and educational researchers. In fact, the research community actively seeks out ways to address students' academic needs by attempting to understand the effect of certain pedagogical moves on students' experiences.

Julian (2017) found that project-based coursework can have an ameliorating effect on students' attitudes towards mathematics. In a quasi-experimental study, they used the Attitudes Toward Mathematics Inventory (ATMI) to survey 41 students before and after a semester of traditional instruction (control group) and project-based instruction (treatment group). They reported a statistically significant increase in students' attitudes towards mathematics for the students involved in the treatment group. In another study, Logue et al. (2016) found that a higher workshop attendance rate can lead to greater increases in positive attitudes towards mathematics. These results imply that a student's attitude towards mathematics can be influenced by a semester of specialized instruction. One of the goals of this study is to investigate the extent to which this is also true of the corequisite model.

Students' Sense of Self-Efficacy

Since students' attitudes are defined by their feelings, beliefs, and behavior (Majeed et al., 2013), this study also aims to understand the effect of corequisite support courses on students' sense of self-efficacy. Self-efficacy is an internal judgment of one's capabilities to perform (Martin et al., 2017), and it is recognized as a predictor of academic achievement (Loo

& Choy, 2013). This construct was particularly interesting to observe since it is more stable than feelings and attitudes (Majeed et al., 2013), and it represents the student's personal assessment of their abilities; this type of self-judgement can shed light on a student's metacognitive abilities.

Perceived self-efficacy is not a reflection of the amount of skill a person has, since people with comparable skills will perform differently depending on their perceived self-efficacy (Bandura, 1993). For example, people with a high sense of self-efficacy are better able to function and stay focused even under taxing circumstances. Hence, a student's beliefs about their abilities can drastically affect how they perform in the classroom. Perceived self-efficacy can lead to raising personal goals, where students can map out routes for success and use them to plan their behavior. Students with lower self-efficacy tend to see routes for failure and obsess on how things can go wrong. This can lead to an avoidance behavior where they shy away from difficult tasks.

Understanding a student's sense of self-efficacy is important because as Bandura (1993) put it,

> The stronger people's belief in their efficacy, the more career options they consider possible, the greater the interest they show in them, the better they prepare themselves educationally for different occupations, and the greater their staying power and success in difficult occupational pursuits (p. 135).

In other words, a student's sense of self-efficacy can affect their future goals and plans. By identifying cases of low-efficacy and the sources of a student's sense of self-efficacy, instructors can plan interventions to support the student in their endeavors.

It is worth noting that in Martin et al.'s (2017) investigation into the impact of DE on students' academic self-efficacy, they did not find a statistically significant change in students' perceived self-efficacy by the end of the semester. This may imply that providing students with academic support does not necessarily change their beliefs about their abilities. This finding is counter to the assumptions that guide this research. The main assumption of this study is that the activities that transpire within corequisite courses can have a positive effect on students' sense of self-efficacy. The rationale for this assumption is that when a student is placed in a college-level course with concurrent support, their sense of ability can potentially increase since they are able to progress with their "college-ready" peers while addressing educational gaps as they arise. In addition, the cohort of students enrolled in the corequisite course can potentially form a supportive community outside of the parent course which can help in building a personal sense of ability. This sentiment was echoed by Voigt et al. (2019), "student persistence in STEM is a dynamic relationship between the opportunities for socially connecting with peers while at the same time developing strong academic ties that function as supports" (p. 3).

The Effect of the Instructor

When studying the classroom environment, it is also important to recognize that the instructor can have a significant effect on the student. As highlighted earlier, the type of instructor that a student has in their initial course can affect how they perform in their subsequent course (Burgess & Samuels, 1999; Fong et al., 2015). Instructors can also affect students based on the beliefs and expectations they have of them. When faculty have low beliefs and expectations of their students, they create environments conducive towards diminishing students' sense of self-efficacy (Bandura, 1993). Students who are taught by such instructors are more likely to have lower performance expectations, which will then affect them in the subsequent courses they attempt. Bandura (1993) recommended that instructors find methods of building students' sense of efficacy so that they can approach difficult tasks as accomplishable obstacles. He suggested fostering a collaborative learning environment where ability is conceived as an acquirable skill.

The corequisite courses can potentially serve as this vehicle for supporting students in developing metacognitive practices, fostering positive attitudes towards mathematics, and building a sense of self-efficacy. Bandura's ideas about creating learning environments to promote greater self-efficacy were also shared by the instructors at the University of Houston-Victoria, who were involved in a pilot study where corequisites were incorporated in English and mathematics courses (Pittendrigh et al., 2020). There was an intentional focus on incorporating strategies and activities around metacognition and self-efficacy. One instructor expressed the desire that "through writing, students will consolidate their learning, take ownership of their own choices within the learning process, and become more aware of their own efficacy" (p. 14). In their study, instructors and instructional leaders began to realize their impact on student learning. Thus, in designing corequisites, it is imperative that course developers focus not only on the content but also on ways to support instructors in creating these safe and productive learning environments.

Classroom Participation

Finally, classroom participation, especially talk-based participation, is an important part of student learning (Banes et al., 2020; Bransford et al., 2000). However, there has been a great amount of research in the education literature around the imbalance of power and agency that may manifest through classroom discourse (Clarke et al., 2016; Neal, 2008), and how inequities may occur in classroom participation (Black, 2004; Reinholz & Shah, 2018; Shah & Lewis, 2019). Thus, while the classroom is a critical site for student learning, it can also become a source of student marginalization.

Active learning has been cited as a potential pedagogical strategy for increasing student engagement (Freeman et al., 2014; Prince, 2004), and leveling the instructional playing field

(Laursen et al., 2014). Such pedagogical innovations encourage active student engagement in the classroom, which is important for identity development (Gresalfi et al., 2019). However, many studies have also showcased how active learning may not always cultivate equitable classroom experiences (e.g., Ernest et al., 2019; J. L. Smith et al., 2019; Stone-Johnstone et al., 2019). Aguillon et al. (2020) highlighted the importance of active learning pedagogy that simultaneously incorporated equitable and inclusive practices. Thus, I hypothesize that corequisite courses that simultaneously stimulate active student engagement while attending to equity and inclusive classroom environments will support student learning.

Theoretical Frameworks

Three frameworks guide the research agenda: the sociocultural theory of learning, Bandura's (1997) efficacy theory, and the Four Frames model for systemic change (Bolman & Deal, 2008; Reinholz & Apkarian, 2018). The sociocultural theory acknowledges the effect of the environment on student engagement and identity-building. Bandura's (1997) efficacy theory identifies specific elements from the environment that contribute to students' sense of ability. The Four Frames model provides a global lens, where the institutional change initiative (from prerequisites to corequisites) is negotiated and adopted by institutional stakeholders and change agents.

Sociocultural Theory

Sociocultural theory focuses on the relationships between people, contexts, actions, meanings, communities, and cultural histories (Robbins, 2005). The unit of analysis is not merely the student but the student within their learning environment (Esmonde, 2017); this is important because learning may shift within different contexts. One central argument in sociocultural theory is that all learning is social (Walshaw, 2016). In his writings, Vygotsky highlighted the dynamic interdependence between social and individual processes in cognitive development (John-Steiner & Mahn, 1996). He suggested that learning begins interpersonally (socially) and then evolves to the intrapersonal (mental) level (Confrey, 1995; Culligan, 2013). Hence, students learn by depending on their instructor and peers with more experience before participating in the environment (John-Steiner & Mahn, 1996).

In general, sociocultural theory suggests that through participation students develop strategies, learn cultural meanings, acquire language, and form relationships. It is also through this appropriation of culture where students shape who they are and construct their own identities (Walshaw, 2016). Social recognition is needed in order to be considered as a knowledgeable person within a community (Esmonde, 2017). In this sense, social relationships can both enable and constrain a student's agency; self-efficacy is a primary factor of student agency (Van Dinther et al., 2011). One constraint to student agency is restrictions on who is permitted to participate within the classroom community. All these factors are important to study for understanding the effect of certain learning environments on students' learning.

Bandura's Efficacy Theory

Bandura's theory on self-efficacy aids in understanding how students' engagement in the class impacts their perceptions of self-efficacy, and vice versa. As Bandura (1997) put it, efficacy beliefs are the basis for action and these beliefs guide students' action or inaction. Bandura outlined four sources of self-efficacy: enactive mastery experience, vicarious experience, verbal persuasion, and physiological and affective states. Identified as one of the strongest sources of self-efficacy (Loo & Choy, 2013), enactive mastery experience refers to the effect that a direct experience of success or failure has on one's beliefs about one's ability to perform a task. While a success may strengthen a student's sense of self-efficacy, a failure can diminish this feeling.

Vicarious experience refers to the effect that other people's performance has on a person's own beliefs about their capabilities. By comparing oneself to peers, or role models, a student can make an appraisal of what is possible to achieve. The people with whom one compares oneself influences how they judge their own ability (Bandura, 1993). For instance, if a person with similar academic characteristics succeeds at a task, a student may be inclined to believe that they are also capable themselves. So, while a failure can diminish a student's sense of efficacy (e.g., mastery experience), being part of a community of learners can increase efficacy. Nickerson, Sei, Ko, and Marx (2017) demonstrated this in their research on female peer role models. They found that female peer role models (in-group members who succeed despite negative stereotypes of ability) can increase mathematical self-efficacy of women who identified with mathematics. Thus, through vicarious experiences of success a student can amend their beliefs about their own ability.

The third source of self-efficacy is verbal persuasion, which refers to the idea that one's sense of capability can be affected by appraisal from influential people within the community; this can be anyone from a significant other to a college instructor. These types of encouragement from others, especially those considered as knowledgeable, can affect how a student perceives their own abilities. The last source of self-efficacy, as outlined by Bandura (1997), is physiological and affective states. This source consists of emotional and physical states (e.g., depression) that can affect the way students perceive their capabilities.

A community of learners can nurture efficacy beliefs among its members by fostering a supportive and collaborative community; corequisite courses can potentially function as a source of positive efficacy beliefs. Understanding each of these sources of students' sense of efficacy can help an instructor structure their class time and provide appropriate feedback to students in a non-generic way. In other words, understanding what impacts students' sense of self-efficacy can allow for the instructor to tailor instruction and customize academic supports.

The Four Frames Model

The final framework that guides this research is the Four Frames model for systemic change. This model is typically used to guide (for a change agent) or understand (for a researcher) change initiatives within STEM departments (Bolman & Deal, 2008; Reinholz & Apkarian, 2018). Each of the four frames are important in creating and sustaining cultural change at an institution. Reinholz and Apkarian (2018) define culture as "a historical and evolving set of *structures* and *symbols* and the resulting *power* relationships between *people*" (p. 3). Since the corequisite model was a relatively new model at Grizzly State University (GSU), the institution of study, the Four Frames model can help illustrate the mechanisms that govern the acceptance and adoption of the model. This model is a useful framework for understanding the institutional contexts that guide the change initiative at GSU.

The first frame, *structures*, refers to the roles and responsibilities that govern how people engage with each other. For a change effort to be sustainable, structures must be amended, and incentives must be offered to encourage support for the change initiative. *Symbols* is the second frame, which represent the values and language that guide decision-making (Reinholz & Apkarian, 2018). Since symbols give meaning to structures, a symbolic shift must coincide with a structural shift. The third frame is *people*, who represent the constituents that compose the community. Since departmental culture is defined by the varying perspectives of the people who make up the department, change initiative must consider multiple perspectives in creating a shared vision for change. Finally, the fourth frame is *power*, which represents the hierarchical nature of communities. Status positions some people over others and interactions are mediated by power dynamics. Reinholz and Apkarian (2018) argue that a change effort must involve all actors, regardless of their status. This means that students, though they tend not to wield as much power as their instructors and campus administrators, should have some input and their experiences accounted for in implementing change.

In light of legislative mandates that brought about the corequisite model, faculty and staff members are scrambling to create a curriculum that covers all the necessary prerequisite content while also satisfying the mandates (Bracco, 2019). It is important to involve the relevant stakeholders in designing the institution’s corequisite supports (Daugherty et al., 2018). This is exactly what the tribal college did in the study conducted by Lundberg et al. (2018), where tribal college faculty were part of the curricular design process. At this institution, various *people* involved in the DE program wielded *power* to create *structures* to implement change at their institution. To ensure that the change initiative was implemented appropriately, the institution prioritized hiring qualified instructors who cared about making math matter to students who feared it (*symbols*); this was an identified student concern that the change agents wanted to ensure was attended to.

Applying the Frameworks

Students’ experiences in mathematics are influenced by institutional and classroom factors. These factors help shape their attitudes and beliefs about mathematics, and their future goals. The three identified theoretical frameworks helped in understanding the relationship between the institutional context, the classroom environment, and the student experience. The Four Frames model provided a global lens to examine the cultural change towards adopting the corequisite model. Sociocultural theory aided in characterizing the classroom environment and how students interact within that environment. Efficacy theory was used to understand how aspects of the environment affected student behavior and their perceptions of their abilities. In the following chapter, I will discuss in greater detail how these theoretical frameworks were operationalized in data analysis.

Chapter 3: Methods

This study aims to characterize the corequisite model at a four-year institution during the start of the third academic year of implementation. It also aims to understand how students engage in corequisite courses at the institution and analyze the effect of corequisites on how students orient themselves towards mathematics. The methods used to address these three research goals are presented in this chapter. The chapter begins with a description of my positionality and my motivations for doing this research. I then provide a broad description of the setting in which the data were collected. Following, is an outline of the data sources. The final section consists of the analytic methods used for addressing each research goal.

Researcher Positionality

I identify as a Black woman of Jamaican parentage, and I come from a line of educators and principals. Being a first-generation natural-born American citizen, my parents pushed me to work hard and excel academically. I was taught to pull myself up by the proverbial “bootstraps” and to tirelessly persist towards my goals. In fact, throughout my academic journey I was surrounded by Black and Latinx students from immigrant families who saw no bound to their academic trajectory due to the expectations set by their family members. This included students at the Philippa Schuyler Middle School for the Gifted and Talented, students accepted as A Better Chance scholars in high school, and students inducted as Ronald E. McNair scholars at their undergraduate institutions.

It was not until I entered the classroom as a lecturer at a community college that I realized that some people do not have boots. The proverbial phrase “pulling yourself up by your bootstraps” did not account for systemic racism and inequity that foster income inequality and unequal access to educational opportunities. I met students who were just as driven as I was to pursue a STEM career but met academic roadblocks every step of the way. These roadblocks included attending under-resourced schools, having to take a seemingly endless sequence of developmental education courses just to matriculate into a four-year institution, and needing to take out additional student loans to fund their education.

As a new instructor, I did not know how to effectively support these students besides providing endless hours of tutoring outside the classroom. While helpful, this method was not sustainable. I taught five semesters of developmental education and about three years of introductory mathematics courses (e.g., Calculus I and II). A common issue that I faced in the classroom was that students entered with a range of lived experiences and varying degrees of prerequisite academic knowledge. I struggled with trying to support these varying types of learners emotionally and academically, while also ensuring that students left the classroom with the prerequisite knowledge needed for the subsequent course. These issues led me to think deeply about academic support interventions like the corequisite model.

In this study, my positionality has helped me to connect deeply with instructors and students alike. My identity as a former student from a low-income and racially minoritized community, and then as an instructor supporting students from similar backgrounds, has allowed me to empathize with the student struggle of persisting in spite of personal hardship and trying to fit into the STEM community that at times is not welcoming to people that look like me.
In addition, due to the shared academic lived experiences that I had with the instructors, our conversations often went deeper than the interview protocol towards uncovering the corequisite experience at the institution. To that end, this study aims to understand how a corequisite course can be leveraged to support students along their STEM pathways.

Context and Setting

Grizzly State University (GSU) is a large public four-year Hispanic Serving Institution located in the southwestern region of the United States. GSU grants several terminal bachelor's degrees and master's degrees. In addition, they have partnered with local universities to offer several joint doctoral degrees. GSU's student body is diverse, with about 56.6% identifying as women and 57.4% identifying as students of color (e.g., 31.5% Latinx, 4.4% Black, and 0.4% Indigenous). The institution underwent major changes in its course offerings and curriculum in response to an executive order issued by the Chancellor's Office of the state university system. The executive order called for changes to the university placement procedures and academic support opportunities.

The executive order shifted placement power away from the individual universities within the system, and to the governing body of the state university system. The Chancellor's Office took over placement decisions and they categorized students into four groups based on their interpretation of student-readiness for college coursework. The new placement system used multiple measures including high school transcript data (e.g., GPA, and previous coursework), and scores on standardized tests (e.g., scores on AP, and SAT/ACT). At GSU, STEM-intending students who were grouped into the lower categories of placement were placed into College Algebra with a corequisite support. GSU took a comingled approach to corequisites where all students were enrolled in the same three-unit College Algebra lecture course, and those identified as needing support enrolled in an additional one-unit corequisite support course.

Data collection occurred during the Fall 2020 semester, which was during the global coronavirus pandemic. GSU offered eight sections of their College Algebra lecture course virtually, with an average class size ranging from 33 to 47 students. They concurrently offered a single section of corequisite support course, which also met virtually; 24 students were enrolled in this course.

Data Sources

This study was conducted using a convergent mixed methods approach where quantitative and qualitative data were concurrently collected and analyzed (Creswell, 2012). The data sources included institutional data, surveys, corequisite student interviews, lecture student focus groups, interviews of institutional leaders, meeting notes from coordination team meetings, corequisite student journal reflections, and classroom observations (including fieldnotes from the observations). Table 3.1 displays the relationship between the data sources and research goals and questions. These data were used to address the research agenda as well as provide context for the findings.

Institutional Data

Institutional data from the Fall 2020 semester and the previous four academic years were obtained to analyze trends in course outcomes at GSU. These data included course outcomes for the College Algebra course, as well as the Pre-Calculus course, which is the subsequent course for STEM-intending students.

Surveys

At the end of the Fall 2020 semester, all College Algebra students at GSU were solicited to complete a modified version of the Student Postsecondary Instructional Practices Survey-Mathematics (SPIPS) that was developed by Apkarian et al. (2019). This SPIPS was itself a modification of the Postsecondary Instructional Practices Survey, as developed by Walters et al. (2016). The College Algebra instructors offered incentives to students in the form of participation credit for completing the survey. As an additional incentive for completing the survey, students were automatically entered into a raffle to win one of five $30 Amazon gift cards. 132 GSU students completed the survey, a low response rate of about 39% of the enrolled College Algebra students. Only seven of the 24 students enrolled in the corequisite course at GSU responded to the survey. In addition, there was a potential response bias since about 99% of the respondents reported expecting a final grade of C or higher, whereas about 82% of all the College Algebra students received a grade of C or higher. Similarly, all seven corequisite respondents reported expecting a B or higher, whereas about 71% of the corequisite students received a B or higher.

A copy of the SPIPS deployed in this study is included in Appendix A. The version of the SPIPS used in this study was updated to reflect the local context at GSU and the temporal context of virtual learning during a global pandemic. For instance, the original SPIPS contained a question with a drop-down menu asking students where they went for tutoring. Options included the campus tutoring center, office hours, friend, private tutor, extra course sessions, review sessions, and "other." In the modified version used for this study, the corequisite course was listed as an option for extra help. The rationale for including the corequisite course was that I predicted that many students would consider the corequisite course as a source for extra help.

The SPIPS survey was administered through Qualtrics (2018), where survey questions were tailored to different populations of students. Students that were co-enrolled in a corequisite course were presented with additional questions to capture their experience in that course. These additional questions were helpful in capturing the impact of the corequisite course on students' attitudes and beliefs about learning and doing mathematics.

All respondents were asked to reflect on how they spent their time in the virtual classroom, highlight their classroom experiences, as well as disclose their demographic information such as race, gender, major, socioeconomic status, and class standing. Toward the end of the survey, students were asked open-ended questions about the relationship between their personal identities and their experiences in mathematics. There were a series of survey questions that prompted students to reflect on perceived changes in their interest, confidence, and self-efficacy in the course. The SPIPS was used as a data source towards triangulating observed phenomena about the classroom experience when comparing to other data sources, such as classroom observations and student interview data. Furthermore, the SPIPS was useful since the results from this study can be contrasted with results from previous studies that have used this instrument within the context of course variations **(**e.g., Voigt et al., 2019**)**.

Table 3.1. Relationship between data sources and research goals and questions.

Research Goals and Questions		Data Sources
1. Describe an implementation of the corequisite model at a public four-year institution.	a. What are the goals and beliefs of institutional stakeholders as it pertains to the corequisite model? b. How are they working together to ensure the successful implementation of the model? c. What is the nature of the academic support available in corequisite courses?	• Institutional data • Institutional leader interviews • Meeting notes from coordination meetings • Field notes from classroom observations
2. Examine how opportunities to engage in course content are distributed within corequisite courses.	a. How are opportunities to engage in course content distributed in corequisite courses vs. lecture courses? b. How do students in corequisite courses engage in their lecture course?	• Classroom observations • Field notes from classroom observations
3. Understand the impact on the student.	How are students' interests, beliefs, and attitudes around mathematics and mathematics learning affected through enrollment in the corequisite course?	• Survey data • Corequisite student interviews • Lecture student focus groups • Corequisite student journal reflections

Institutional Leader Interviews

Throughout the data collection period, eight institutional leaders participated in semi-structured interviews guided by an interview protocol around their conceptions of and experiences with the corequisite model. The interview protocol was used to guide the conversation while providing flexibility to explore emergent insights from the interviewee (Bernard, 2017; Galletta, 2012). The first group of institutional leaders were instructional leaders that were involved in instructional decision-making for the College Algebra lecture and support course. These individuals included four College Algebra instructors, the College Algebra course coordinator, and an undergraduate learning assistant (ULA). These interviews covered topics related to their perceptions and expectations of the corequisite model, their teaching philosophy, information about the institutional climate around corequisites (including support structures for sustainability and instructor buy-in), and hypotheses they had around student success because of corequisite remediation.

The second group of institutional stakeholders were campus leaders that had some input on the introduction of the corequisite model to GSU's mathematics courses. These individuals included the chair of the mathematics department, and the former Pre-Calculus course coordinator. The chair of the department was selected for an interview because of his role as the head of the department. He would, by default, have input on any changes implemented within the mathematics courses at GSU. The former Pre-Calculus coordinator was solicited for an interview because of her role in helping to establish the corequisite course at GSU. Her role in the evolution of the corequisite course diminished after it was established during the Fall 2018 semester, but I forecasted that she had great insight into how and why the model was chosen for GSU's College Algebra course in the first place. These institutional leaders were asked similar questions as the first group of interviewees. In addition, they were asked to provide a top-level overview of how the corequisite model was introduced and implemented at GSU, their perceptions of success regarding the model, and how the model was being evaluated. A combined institutional leader interview protocol is included in Appendix B.

Corequisite Student Interviews

Students enrolled in the corequisite course were solicited for an interview throughout the semester, beginning after the third observation of the corequisite course. Out of the 24 enrolled students, seven signed up for a semi-structured interview and received a compensation valued at $20. A full table including relevant demographic information (race, gender, and major) of these students are presented in Chapter 6. These students were asked to reflect on their experiences in the lecture and support courses. Interview questions addressed student expectations of the corequisite course, their lived experiences, their relationship with the instructor and their peers, as well any changes to their affective states (e.g., changes to their sense of self-efficacy, attitudes towards mathematics, and confidence) because of their experience in the corequisite course. The corequisite student interview protocol is included in Appendix C.

Lecture Student Focus Groups

Students enrolled in the observed lecture course sections were solicited for focus groups during the final week of observation (twelfth week of the semester). Eight students agreed to participate in four focus groups (two students each). Ultimately, only seven students participated and received compensation valued at $20. One of the students did not show up to the focus group so the scheduled focus group turned into an interview of a single student.

Four of the students were enrolled in Ms. Johnson’s class, and three of them were students in Ms. Martinez’s class. These students were asked similar questions as the corequisite students, but the primary focus of these focus groups was on students' experiences in the lecture course. These focus groups were beneficial for comparing the non-corequisite student experience to the corequisite student experience in the lecture courses. In addition, these students were asked about their knowledge of the corequisite course and if they think they would have benefitted from enrolling in the support course. The lecture student focus group interview protocol is included in Appendix D.

Notes from Coordination Team Meetings

The four College Algebra instructors (Ms. Addison, Ms. Johnson, Ms. Martinez, and Ms. Rose) met weekly to plan and discuss topics related to course content and delivery. There were 15 of these meetings, and the group began meeting one week prior to the start of the Fall 2020 semester. During these meetings, I took notes on the topics they discussed and the nature of their interactions. It was important to understand the connection between the lecture and support course material, and to learn what and how decisions were made. As outlined in Table 3.1, this data source aided in addressing the first research goal of understanding the institutional context.

Corequisite Student Journal Reflections

The corequisite instructor gave students a journal assignment during the ninth and 16th week of the semester, to assess their experience with the corequisite class and course material. This journal assignment was deployed using Google Forms. An example of this assignment is included in Appendix E. The students were asked questions about their experiences in the class up until that point. The form began by asking them to state relevant identification information. Next, they were asked to predict their final course grade in the College Algebra lecture and the lowest grade they would be satisfied with. They were then asked to report the amount of time they spent doing various course-related activities at home (e.g., how many hours spent reading textbook and/or class notes, how many hours spent watching Khan Academy, how many hours spent getting assistance from the campus learning center, etc.). Following, students were asked whether they had a quiet space to work on their math, and about the time of day they typically spent working on math. Next, students were asked to highlight the course activities they found effective and not effective. Finally, they were asked questions about a recent assessment, including specifying the questions they got wrong, the reasons for their errors, what they tend to do after an assessment, and the steps they planned to take to avoid repeating their errors.

Classroom Observations

Classroom observation data was obtained from four lecture sections and the single corequisite course offered during the Fall 2020 semester. Data was collected across three weeks (Weeks 4, 8, and 12). There was a total of 18 observations during the three weeks of data collection – for each observation of the corequisite course, two of the subsequent lectures (taught by different instructors) were observed (see Table 3.2). In other words, the corequisite course was observed six times and the lecture course sections were observed 12 times. The purpose of this observation plan was to capture the corequisite student experience by beginning the day with their corequisite class at 9am, followed by their lecture course which was either at 11am, 12pm, or 1pm. At the start of the study, only the Lecture A1 and Lecture C courses were scheduled to be observed. After the first two days of observation, I realized that only five of the corequisite students were enrolled in those lecture sections. Since the corequisite students were enrolled in any of the eight lecture sections, it was important to observe more than these two lecture sections to capture as many corequisite students within both the corequisite and lecture course; this is how I ended up observing four lecture sections. By the end of the observation period, I was able to capture 13 corequisite students in both their corequisite and lecture courses.

Table 3.2. Observed courses.

Course	Number of Observations	Average Class Size
Corequisite	6 observations	24
Lecture A1	2 observations	44
Lecture A2	2 observations	46
Lecture B	4 observations	33
Lecture C	4 observations	47

Each class (including the corequisite) met around three times a week (Monday, Wednesday, and Friday) for 50 minutes each. More often students would attend these classes only twice a week (Mondays and Wednesdays). As such, classroom observations were planned for Mondays and Wednesdays since those were the days where attendance was higher, and they were also the days when students were not being assessed. For instance, in the corequisite course, the Friday meeting time was mandatory only for those students who did not complete their homework or scored lower than 80% on the homework. In the lecture course, the class would meet on Fridays only when there was a scheduled group quiz – this occurred five times during the semester. The other Fridays were reserved for asynchronous lecture videos and individual quizzes.

Classroom observations were recorded using the Zoom videoconferencing platform. Copious field notes were taken to document the classroom environment. The field notes template is included in Appendix F. Within the field notes document, various details from the virtual classroom environment were captured. These details included the activities that the students were engaged in, student attendance, the type of classroom instruction (e.g., lecture-based, inquiry-oriented, etc.), how students interacted with each other, how the instructor interacted with the students, how many students had their videos on, and how many students unmuted to participate.

Data Analysis

The data described were analyzed using a convergent mixed-methods approach, where both quantitative and qualitative data were used concurrently to address the research goals. In this section, the analytic methods are described for each research goal.

Research Goal 1: Describe an implementation of the corequisite model at a public four-year institution.

A deductive thematic analysis approach (Braun & Clarke, 2006) was taken in analyzing the data for this first goal. Using the MAXQDA 2020 analysis software (VERBI Software, 2019), transcript data from institutional leader interviews and meeting notes from coordination meetings were openly coded using descriptive codes for characterizing the interview responses and observed events (Miles & Huberman, 1994). Since the corequisite model was a relatively new model at GSU, these descriptive codes were then organized along the Four Frames model (Bolman & Deal, 2008; Reinholz & Apkarian, 2018), in order to understand the different aspects of GSU's cultural change towards offering corequisite remediation. This framework was strategically chosen to capture the four features of cultural change, as defined by Reinholz and Apkarian (2018), including the new or adapted institutional *structures*, the shared *symbols* among the *people* within the institution (relevant stakeholders), and the *power* dynamics that influence how people interact.

Structures refer to the routines and practices of the institutional stakeholders that contributed to the functioning of the change initiative. *Symbols* refer to the shared norms and values among the stakeholders. *People* refer to the constituents within the group along with their identities and personal goals. And *power* refers to the group hierarchies and power dynamics that influence how people engage with each other. There were several descriptive codes that did not fit within this framework and will be thoroughly explored in a future analysis. For example, codes around the instructional leaders' (including instructors, course coordinator, and ULAs) perceptions of the student experience were not included in this analysis since it was outside of the scope of this dissertation. Particularly, the goal of Chapter 4 was to explore the change initiative through the eyes of the institutional leaders. The sixth chapter of this dissertation explores the student experience by elevating student voices. A potential future analysis could explore the relationship between the instructors' perceptions of the student experience and students' declarations about their experiences.

Research Goal 2: Examine how opportunities to engage in course content are distributed within corequisite courses.

The primary data source used for addressing the second research goal was the classroom observations and field notes. Classroom participation was quantified using the classroom observation tool EQUIP (Reinholz & Shah, 2018). EQUIP, which stands for Equity QUantified In Participation, is a classroom observation tool that can be used to document and quantify patterns of student participation, and potentially identify inequity within classroom discourse. The unit of analysis in EQUIP is a participation sequence, which is a chain of utterances from a student where a new sequence begins once a new individual enters the discussion.

Table 3.3. Descriptions of EQUIP discourse dimensions.

Dimension	Codes	Descriptions
Solicitation Method	Called On	Instructor calls on a specific student or group of students by name.
	Not Called On	Student begins speaking without being solicited.
	Chat Solicitation	An open solicitation for anyone to respond to a prompt in the Zoom chat, whiteboard, or other non-vocal forms of public participation
Teacher question	N/A	No clear evidence of a recent teacher solicitation
	Other	A general mathematical solicitation.
	What	A solicitation to recall a fact or recite a statement.
	How	A solicitation to report a list of steps.
	Why	A solicitation to share one's reasoning.
Type of talk	Other	Student does not say a mathematical idea.
	What	Student reads our part of a problem, recalls a fact, or gives a numerical/verbal answer without justification.
	How	Student reports on steps taken to solve a problem.
	Why	Student explains their reasoning.
Length of talk	A few words	Single word responses (1-4 words)
	Short response	Single sentence (5-20 words)
	Long response	More than one sentence (21+ words)
Teacher Response	N/A	The instructor does not engage in student's response, or it is not clear which student the instructor is responding to.
	Revoice/Elevate	The instructor re-presents or reformulates a student's ideas such that others can hear/understand it, without evaluating it.
	Evaluate	The instructor assesses whether the student's response is correct without inquiring into their ideas.
Venue	Whole Class	Student unmutes and vocally participates in the main Zoom room.
	Breakout Room	Student unmutes and vocally participates in the Breakout room.
	Chat	Student contributes in the Zoom chat.

Participation sequences from class observations were transcribed and coded along several discourse dimensions to document how the student was solicited for participation, the types of questions the teacher posed to the student, how the student engaged with the teacher's question (length and type of talk), how the teacher responded to the student's ideas, and the venue in which the sequence occurred. A brief overview of these discourse dimensions and codes is displayed in Table 3.3. The Teacher question, Type of talk, and Length of talk dimensions were coded at the highest level of each dimension. The associated codes for these dimensions are listed from lowest to highest in the table. Solicitation Method was coded according to how the sequence was initiated, Venue was coded based on where the interaction occurred, and Teacher Response was coded based on the codes described in the table.

I coded all 18 observations using EQUIP, and four of them were double coded by two graduate students; Coder 1 had previous experience using EQUIP and Coder 2 received training on EQUIP prior to coding. Coder 1 and 2 both coded two different classrooms. Coder 1 and I achieved over 96.5% agreement across all EQUIP dimensions, whereas Coder 2 and I achieved over 93.1% agreement. To account for agreement that may have occurred by chance, I computed Cohen's Kappa for both sets of coders (Hallgren, 2012). The agreement level controlled for chance agreements are displayed in the inter-rater reliability table in Table 3.4.

Table 3.4. Inter-rater reliability statistics via Cohen's Kappa.

	Solicitation Method	Length of Talk	Type of Talk	Teacher Question	Teacher Response	Venue
Coder 1 (N = 144)	98.4%	91.2%	97.1%	94.3%	93.9%	100.0%
Coder 2 (N = 72)	100.0%	100.0%	90.3%	86.4%	100.0%	100.0%

From the EQUIP data, information about who participated, how often they participated, and the nature of their participation was documented and aggregated for each course. These data were then broken down by major, gender, race/ethnicity, and support status (whether they were enrolled in the corequisite course). Classroom demographics data were self-reported through a demographics survey disseminated at the start of the semester. Patterns of participation in the corequisite and lecture courses were then analyzed via Chi-squared testing using an expected distribution relative to the demographic make-up of the classroom, and computations of equity ratios. An equity ratio is a quotient of a group's actual participation to their expected participation based on their representation in the class (Reinholz & Shah, 2018). This value uses equality as a baseline for equity with the understanding that for students from marginalized backgrounds, a value less than 1 (proportional participation) may signify inequity. In instances where a potential inequity may have been present, subsequent qualitative analyses were done to understand the quantitative findings. The analyses focused on differences in student engagement between the corequisite course and the lecture courses, and differences in participation patterns of the corequisite students in their corequisite course and their lecture course.

Research Goal 3: Understand the impact on the student.

Survey data from the SPIPS, transcripts from corequisite student interviews and lecture focus groups, and corequisite student reflections from the ninth and 16th weeks of the semester were the data sources used to understand the impact of the corequisite course on the student. Only the completed surveys were used for analysis, thus only 117 survey responses out of the original 132 were used. Descriptive statistics were computed for survey items related to the classroom experience within the lecture courses. These data were considered both in the aggregate and by instructor. These data were also used to contrast the seven corequisite respondents' experiences to the 110 non-corequisite (lecture-only) students' experiences. SPIPS data related to students' attitudes towards mathematics and beliefs about learning were isolated and analyzed using a paired samples t-test to measure differences from the beginning to the end of the semester.

Open responses in SPIPS, the transcripts from the interviews and focus groups, and corequisite student journal reflections were then analyzed using an inductive thematic analysis approach, where salient and common themes were identified throughout the data (Braun & Clarke, 2006). This analysis occurred in six phases. In the first phase, interview data were transcribed and read, and interesting details were annotated. Afterward, initial codes were generated based on salient features throughout the dataset (see example in Table 3.5).

Table 3.5. Example from second phase of thematic analysis.

Data	Initial Codes
"So, for my degree evaluation it says that I need to take this class, but when I took the placement test I actually scored to be in [Pre-Calculus] … I think, I can't exactly remember but I would still have to take the [corequisite] class. Like no one told me. It was just on my degree evaluation that in my first year at [GSU] I have to take this class to complete the requirement."	Code 1 – Degree evaluation informs students of needed classes. Code 2 – Student can take placement to place out. Code 3 – Placement test results conflict with Chancellor's placement. Code 4 – Lack of advisement to complement degree evaluation.

In the third phase, codes were grouped according to themes with supporting evidence. The identified themes were then refined by investigating whether the meanings were valid in relation to the data set, and whether they worked. Afterwards, themes were explicitly named and defined in accordance with what it described and the details from the data that was captured by the theme. Finally, a second coder was consulted to double code a subset of the interview data to ensure consistency and clarity among the themes. Through conversations about the subcodes, about the relationship between the subcodes and theme, and about the data itself, we became more aligned around the identified themes. The main themes that arose out of the data were *placement*, *virtual engagement*, and *student affect* (See Figure 3.1). At this point, it was apparent what the different themes were, how they fit together, and the general narrative that they revealed about the data (Braun & Clarke, 2006) – this is presented in Chapter 6. A longer description of the themes and sub-codes are included in Appendix G.

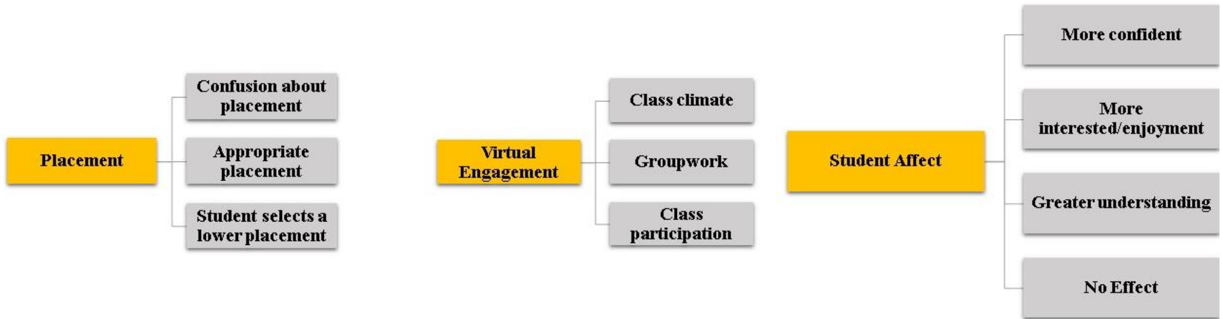

Figure 3.1. Themes from the thematic analysis of student interviews.

Chapter 4: The Institutional Change

In this chapter I address the first research goal of describing an implementation of the corequisite model at a public four-year institution. I achieve this goal by describing the institutional context for enacting the corequisite model at Grizzly State University (GSU). It is important to understand the local context of a change initiative in order to determine the local factors that contribute to the outcome of the change. Using the Four Frames methodology (Bolman & Deal, 2008; Reinholz & Apkarian, 2018) as an analytic framework, GSU's adaptation of the corequisite is explored in this chapter.

The chapter begins with an outline of the methodological approach. Then, a delineation of the sequence of events that led to the Fall 2020 iteration of the corequisite model is provided. This occurs first by presenting the motivation for the shift to corequisites in Fall 2018, and then illustrating the evolution of the corequisite course from Fall 2018 to Fall 2020. A summary of the change initiative is presented in the penultimate section. And finally, the chapter concludes with a discussion of the various factors that have contributed to GSU's flavor of the corequisite model towards answering the following research questions:

a. What are the goals and beliefs of institutional stakeholders as they pertain to the corequisite model?
b. How are institutional stakeholders working together to ensure the successful implementation of the model?
c. What is the nature of the academic support available to students in corequisite courses?

Methodological Approach and Data Sources

GSU incorporated corequisite support courses in various mathematics courses including their general education course, their statistics course, and their College Algebra course. The

College Algebra corequisite is the focus of this dissertation because College Algebra tends to be the first math course taken by STEM-intending students who do not place directly into Pre-Calculus or Calculus I.

There were two primary data sources used to capture GSU's context for executing the corequisite model in the College Algebra course. The first data source was researcher notes from weekly College Algebra coordination meeting. The group of College Algebra instructors and course coordinator met weekly beginning the week prior to the start of the Fall 2020 semester. There was a total of 15 of these meetings during the Fall 2020 semester, where the group discussed topics related to course content and delivery as well as any emergent topic that arose throughout the semester.

The second data source was interviews of select institutional stakeholders related to the College Algebra course. Table 4.1 includes relevant details about the interviewees. The course instructors were asked to reflect on their experience teaching College Algebra at GSU, to describe their pedagogical approach, and to reflect on their experience with and/or perceptions of the corequisite support course at GSU. The undergraduate learning assistant (ULA) was asked about her role in the College Algebra lecture and/or support course, about her experiences in the classroom, and her perception of the corequisite support course and its efficacy. There were three other institutional stakeholders interviewed, who were not teaching College Algebra during the Fall 2020 semester, that had some impact on the creation of the corequisite course at GSU and/or the present course delivery. They included the chair of the mathematics department, the former Pre-Calculus course coordinator, and the current College Algebra course coordinator. These individuals were asked broader organizational questions around the origins of the corequisite model at GSU, its evolution at GSU, and their general perceptions about the efficacy of the model.

Table 4.1. Interviewed institutional stakeholders.

Individual	Position	Gender	Race/Ethnicity	Years at GSU
Kristen	Undergraduate learning assistant	Woman	Mixed Race *(White/Latinx)*	Two semesters
Ms. Addison	Lecturer	Woman	Mixed Race *(Asian/Middle Eastern)*	Three years
Ms. Johnson	Lecturer	Woman	White	Eight years
Ms. Martinez	Lecturer	Woman	Latinx/Hispanic	Three years
Ms. Rose	Lecturer	Woman	White	One semester
Dr. Gilbert	Former Pre-Calculus course coordinator	Woman	White	25 years
Dr. Stevens	Chair of mathematics department	Man	White	21 years
Dr. Washington	College Algebra course coordinator	Woman	White	Three and a half years

Data Analysis

The data was analyzed using a deductive thematic analysis approach (Braun & Clarke, 2006) with the Four Frames model (Bolman & Deal, 2008; Reinholz & Apkarian, 2018) as an a priori framework. The Four Frames model is useful for examining and understanding how change occurs within an organization. The four defined frames in this model are *structures*, *symbols*, *power*, and *people*, and each of these frames provide a lens through which we can understand cultural change within an organization. Culture, as outlined by Reinholz and Apkarian (2018), is defined as "a historical and evolving set of *structures* and *symbols* and the resulting *power* relationships between *people*" (p. 3). The corequisite model was a new structure put in place to address issues around student attrition and preparedness for STEM majors and careers. Through the lens of the Four Frames, the institutional change initiative was documented and the mechanisms that have contributed to the functioning of the corequisite model are specified in this chapter.

The data analysis began with open coding of transcript and meeting notes, where descriptive codes were generated to characterize the events observed and reported (Miles & Huberman, 1994). Codes were then organized around the four themes which are delineated in the Four Frames model; these include *structures*, *symbols*, *people*, and *power*. Again, these four frames are together important in understanding culture towards advancing sustainable change within an organization. *Structures* refers to the roles and responsibilities that govern how people engage within the organization. *Symbols* represent the values and language that guide decision-making. *People* represent the diversity of thought and identities of the stakeholder within the organization. And *power* represents how status influences how people perform within an organization, and how resources and stakeholders are leveraged towards cultural change. The analysis explored the institutional *structures* that emerged to support the corequisite model at GSU, the *symbols* in the form of values (whether old or new) that contributed to the change happening at GSU, the *people* who operated within the system, and the *power* dynamics that influenced how the model functioned and was taken-up at GSU.

Corequisites: The Origin Story at GSU

Like at many institutions nationwide, the Chancellor's office of the larger university system (of which GSU is part) wrestled with issues of student attrition and extended time to degree completion. Systemwide, a large share of admitted students were deemed not "college-ready" and would need to take at least one developmental education course. This problem tended to disproportionately affect low-income students, first-generation college students, and racially minoritized students. To counter these systemic problems, the Chancellor's office instituted an executive order with many goals including, improving placement and assessment, and restructuring/eliminating developmental education.

The executive order was to be implemented within a year after it was announced, and it primarily addressed issues that affected students enrolled in foundational writing and mathematics courses. The order mandated that students be placed directly into college-level courses upon enrollment at the university. This was an intentional move away from the developmental education sequence of courses that hindered students from completing their degree within a reasonable timeframe (four-five years). The order also issued guidance to institutions for providing academic support for those students who normally would not place directly into college-level courses. Specifically, the order mandated the adoption of academic support models such as the corequisite model to help prepare and support students in their general education mathematics and writing courses.

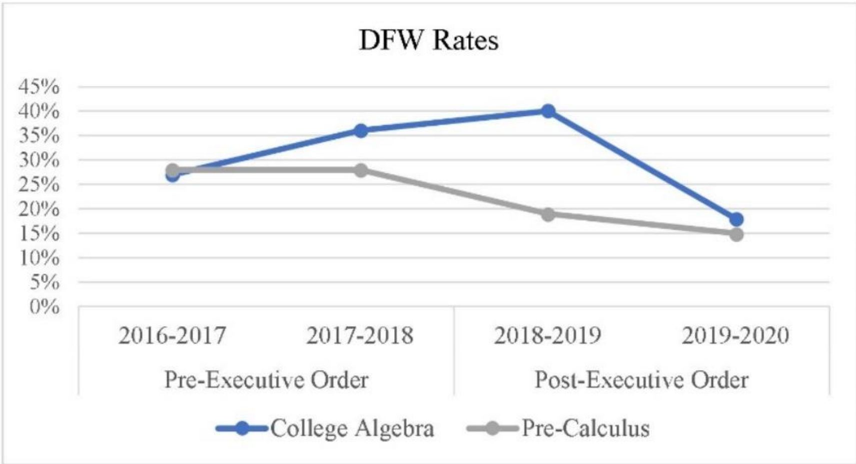

Figure 4.1. DFW Rates pre and post the executive order.

The systemwide problems that motivated the executive order were also present at GSU. Prior to the executive order, the DFW rates (percentage of students that receive a grade of D, F, and W) in introductory (gateway) mathematics courses like College Algebra and Pre-Calculus courses were consistently higher than 25% (see Figure 4.1). This was alarming since these were the courses that STEM-intending students needed to take if they did not place directly into the Calculus sequence. During the first academic year after the executive order, the DFW rates increased for College Algebra while decreased for the Pre-Calculus course. This increase may have been due to an increased number of students now being placed into College Algebra, and the unpreparedness of the institution to immediately and effectively implement the top-down changes from the Chancellor's office. Regardless of the specific cause for the increase in DFW rates in College Algebra, the executive order became the impetus for cultural change at GSU. Through the Four Frames methodology, I was able to tease out features that contributed to the products and processes of the cultural change at GSU. This change came in the form of new institutional leaders (*people*) to spearhead the change initiative, modified institutional *structures* to facilitate the change, a continuous negotiation of norms and values (*symbols*), and a shifting of *power* in placement decisions along with the inherent power dynamics that affected how the relevant stakeholders navigated GSU's cultural change.

By the 2019-2020 academic year, the DFW rates decreased for both College Algebra and Pre-Calculus (below 20%). It is worth noting that the second half of that academic year marked the beginning of a global pandemic, and GSU like other institutions worldwide became more lenient with late withdrawals, final grades, and allowing students to switch grading options to credit/no credit. Even so, looking at the Fall 2019 semester (prior to the pandemic), the DFW rates were 20% and 17% for College Algebra and Pre-Calculus respectively (see Figure 4.2). So, while there was a 2% increase for Pre-Calculus, there was a steep (20%) decline for the College Algebra course compared to the previous academic year. In the following sections, I outline some of the structural changes that arose from the institutional change initiative in response to the executive order. I infer that these changes contributed to the declines in DFW rates for the College Algebra course during the second academic year (2019-2020) post-executive order.

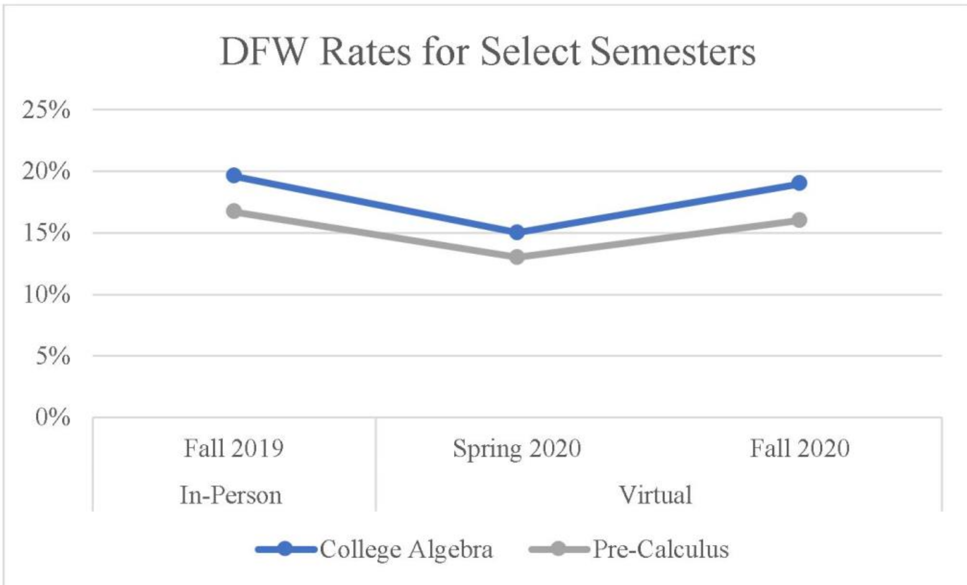

Figure 4.2. DFW prior to the study.

Structures

With the executive order came an influx of money towards structural changes at the institutional level. One major structural change that occurred at GSU was the hiring of Dr. Washington as the course coordinator for the College Algebra course. In addition to being a tenure-track faculty in the mathematics department, her teaching, service, and research activities were tied to issues related to the executive order. Specifically, one of the primary goals for her position was to execute the changes recommended by the Chancellor's executive order. In addition to this major structural change at GSU, there were at least three other structural changes that occurred in response to the executive order. There was an update to GSU's Mathematics Support Center, a change in student placement procedures, and the creation of a corequisite course for several lower division math courses (including College Algebra).

Mathematics Support Center

GSU's Mathematics Support Center is geared towards helping students enrolled in gateway STEM courses, including introductory mathematics courses like College Algebra, Pre-Calculus, Calculus I and II, and Statistics. Prior to the COVID-19 pandemic, this center housed office hours for instructors and teaching assistants. This center also provided students with one-on-one tutoring in most of their introductory STEM courses – this service shifted to the virtual environment (Zoom) during the pandemic. Even with such flexible services, many students in the gateway mathematics courses did not take advantage of them. As described by the former director of the center, Dr. Gilbert, students would often report not knowing of its existence though the Mathematics Support Center was centrally located within one of GSU's libraries.

There were many changes made to the Mathematics Support Center, some cosmetic and others structural. One cosmetic change was the installation of carpet. Though this change may seem insignificant to some, Dr. Gilbert felt this change could potentially lead to more students frequenting the center. She explained, "we wanted more [students in gateway courses] to come to the [center] instead of just the calculus people." Students enrolled in College Algebra and Pre-Calculus rarely attended office hours or tutoring at the center, while students in the Calculus sequence frequented the center much more often. Dr. Gilbert predicted that the cosmetic changes to the center would help motivate students to spend more time working in the center.

The biggest structural change to the center was the hiring of a new associate director, Dr. Washington. Directing the Mathematics Support Center was another aspect of Dr. Washington's position at GSU. Dr. Washington and Dr. Gilbert worked together to create a space for students to seek academic assistance and to engage openly with their course materials. They implemented incentive programs to motivate students to visit the center. For instance, Dr. Washington coordinated with the College Algebra instructors to create a Scavenger Hunt activity where students would visit the center and meet with one of the center's tutors. The rationale for such activities was to get students into the center, and from there, the environment (with the help of a cosmetic makeover) would encourage students to stay longer and/or revisit the center.

Placement

Prior to the executive order, all students planning on enrolling in a mathematics course at GSU were required to take an in-house entrance exam for placement. The university also used ALEKS®, an adaptive learning and assessment software, to place students out of lower division math courses. The executive order restricted these types of placement measures. Specifically, GSU was no longer able to use an entrance exam to place students into lower division mathematics courses. As part of the executive order, the Chancellor's office took control of these placement decisions by creating four levels in which to categorize student readiness for college-level mathematics. These categories were based on multiple measures including high school grade point average, high school transcript, and scores from standardized assessments (e.g., SAT and ACT). Beginning in the Fall 2018 semester, GSU no longer required students to take the in-house entrance exam and relied solely on the student's ranking along the Chancellor's categorical scheme for placement into the lower division mathematics courses. STEM-intending students categorized in the third and fourth categories were recommended to take College Algebra with a corequisite support course.

One significant change that occurred in response to the shift in placement procedures was reflected in the number of students enrolled in Pre-Calculus. Dr. Gilbert shared,

> I mean it used to be that Pre-Calc was the lowest class … we had over 700 students, instead of now, we only have like maybe 350. And so, you know we were trying to deal with a range that was just so huge. So that's been a big help to take out you know the students who need more attention.

Dr. Gilbert was simultaneously the director of the Mathematics Support Center and the course coordinator for the Pre-Calculus course. Prior to the executive order, more of GSU's STEM-intending students began their collegiate journey in the Pre-Calculus course. This meant, as detailed by Dr. Gilbert, there was a large number of students enrolled in Pre-Calculus with varying degrees of academic preparation. Thus, GSU had a different placement problem than other institutions in their university system. At other institutions, many STEM-intending students with underdeveloped mathematical skills began their academic journey in a developmental sequence which had various negatives effects on student persistence and retention (e.g., extending the time to degree completion). At GSU, these same types of students were either placed directly into Pre-Calculus (without support) or College Algebra (without support). STEM-intending students that needed more prerequisite support had to rely on other avenues of support outside of the mathematics department, including enrolling in developmental courses at local community colleges. Though GSU did not officially recommend this option, Ms. Johnson (one of the College Algebra instructors) highlighted the community college option as a route some of her students had taken in the past.

As Dr. Gilbert and Dr. Stevens (chair of the mathematics department) suggested, the range of academic abilities within the Pre-Calculus courses was a major challenge to teaching mathematics well at GSU. It posed an added burden to the instructors and the students who were not adequately supported in those settings. The executive order brought new placement procedures which resulted in less students being placed directly into the Pre-Calculus sequence, and more students beginning at College Algebra, with or without a corequisite support. This change is illustrated in Figure 4.3, where the number of Pre-Calculus students was halved from the Fall 2017 semester (the beginning of the last academic year pre-executive order) to the Fall

2018 semester (the first semester of the implementation of the executive order). Due to the new placement procedures, enrollment in the College Algebra course ballooned as more students were shifted from Pre-Calculus to College Algebra. Fall 2018 was also the first semester of the corequisite support course for College Algebra.

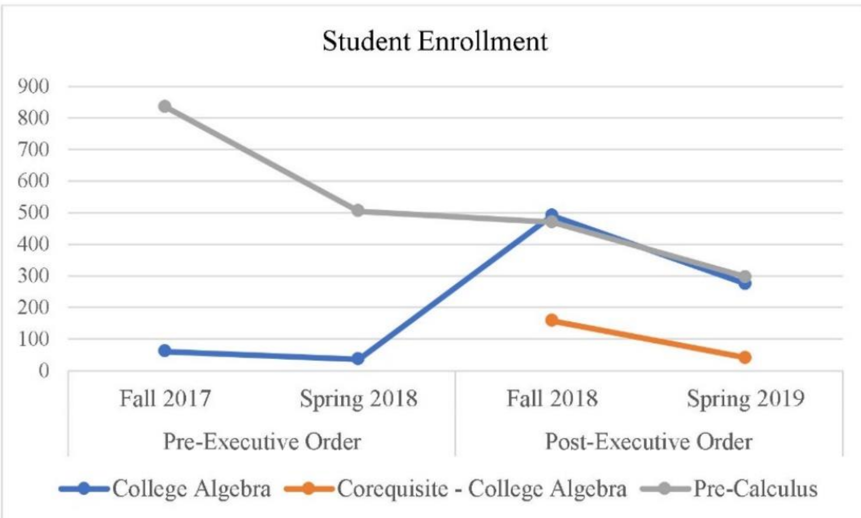

Figure 4.3. Student enrollment before and after the executive order.

More Placement Issues after the Executive Order. Placement decisions were primarily controlled by the Chancellor's office after the executive order. Though the executive order was meant to streamline and minimize placement inconsistencies, even up until the Fall 2020 semester, GSU still experienced problems with student placement. There were College Algebra students that needed the extra academic support of the corequisite but were not placed in the support course, and vice versa. This problem led to the need for the College Algebra instructors to cover more prerequisite content in the lecture course to make sure that all students were getting the support they needed to engage with the College Algebra course content. Doing more review in the lecture course came at the cost of not covering all the College Algebra material, which was prerequisite content needed for the Pre-Calculus course. Thus, this was a systemic problem that had the potential to affect student outcomes beyond just the College Algebra course.

To navigate this issue of misplacement, some instructors informally invited lecture students to attend the support course since there were no ways for students to proactively enroll in the support course. One instructor stated,

> I did have a student in my lecture that I think that she would have needed that extra … She was a student who was always either confused. I would think that she was not paying attention, but she was … because she was engaged, but she really didn't know what was going on … And even though in my office hours when I would still go over it, she was like yes and no. So, I talked to the student and I said you know what, I highly recommend you come to my [support course]. Like, I don't care, just come because you need it.

This instructor realized that just attending office hours was not sufficient for helping this student. She invited the student to attend the support course because she realized that the corequisite provided an additional opportunity for students to learn the material and develop the skills they need to be successful in the lecture course.

The Corequisite Course

The corequisite support for the College Algebra course was a new structure created in response to the executive order. The corequisite course at GSU was implemented using a comingled approach where a group of students (identified by the Chancellor’s office) would take their College Algebra lecture course with all other College Algebra students, and then meet for additional hours of the week in a corequisite support workshop. The corequisite students did not necessarily enroll in the same lecture course, but they all were enrolled in a support course together. During the first academic year after the executive order more students were recommended to take College Algebra, and about 26% of all College Algebra students were recommended to take the corequisite support course in conjunction with their College Algebra lecture course.

Dr. Gilbert (former course coordinator for Pre-Calculus) and Dr. Stevens (chair of the mathematics department) worked together to develop the curriculum and syllabus for the new lecture and support courses. The support course was designed to be a course for preparation and just-in-time remediation for the lecture course. When asked about his perceptions of the corequisite model, Dr. Stevens responded:

> The corequisite is one of the few different options, I think another model that people use is stretch courses. And then there's also sort of a boot camp approach where students come in the summer before and try and get up to speed. I don't know what works better, and I'm not sure any data would really convince me because schools are so different you know … you really have to work a long time at this to figure it out. How the model works depends on the individual school and the type of student body they have. And it depends on the particular instructors you have, and their training and all that.

The Chancellor's office suggested a few academic support options, one being the corequisite model. Dr. Stevens recognized that there were many models and many ways to implement the corequisite model, and further, he was not sure which flavor of the corequisite model was the most effective model considering that institutional factors can affect implementation. He added,

> I'm not completely sold on the corequisite model. It's like I said, we adopted it, because it seemed like the thing that we could do without ... with the minimum amount of disruption and we wouldn't make big mistakes.

His rationale for choosing the corequisite model as opposed to a stretch model (extend course over two semesters) was that it was logistically easier. The corequisite model required adding additional courses and finding instructors to teach them. A stretch model required all those things, and more – this included more planning, more academic resources, more course sections, more iterations (especially in instances when a student fails the first semester), and more communication with upper administration around other logistical elements (e.g., enrollment management system). Since Dr. Stevens was not particularly "sold" on any model of academic support, he chose the model with what he called the "minimum amount of disruptions."

One success of the model was the fact that GSU was able to keep the corequisite classes small. Unlike the lecture courses, which typically had over 50 students enrolled in each section during the in-person setting and between 40-50 students on average in the virtual environment, the corequisite courses intentionally had a 30-student capacity. Smaller class sizes meant that students were able to have more intimate relationships with their classmates and more one-on-one time with their instructor. In these settings students may feel more inclined to seek help and engage with the material.

By the start of this research, GSU had implemented this model for two academic years. Data collection occurred during the third academic year; this was a year plagued by a global pandemic. Dr. Stevens described the three-year period as a "difficult period" in navigating this new structure. While he believed that there was good progress in the development of the corequisite support course, he was unsure about the effect of the model on student outcomes in subsequent courses. He explained that while corequisite students may be doing better in the College Algebra course, "that doesn't mean that they've achieved a certain level of math because you taught them enough to get through [the] particular course that it was targeted." He reiterated,

> I'm not, like I said I'm not completely sold on the corequisite model. I think that what we've done in terms of using it to prepare students for that week's classes, is probably the right thing to do; and I think it's worked pretty well. But I do need to hear more from students.

Before Dr. Stevens could evaluate GSU's implementation of the corequisite model in their College Algebra class, he wanted to see more evidence and to hear how students responded to it. Thus, this current research is timely in that results from this study can be used to help inform the next iterations of the corequisite design at GSU. It is also beneficial for institutions that are brainstorming academic support strategies for their lower division courses. This dissertation provides the institutional context for implementation (present chapter), a description of how students engaged within the classroom (Chapter 5), and an account of students' perceptions of the experience (Chapter 6).

The Evolution of the Support Course

There were many institutional stakeholders (*people*) involved in the creation and the development of the College Algebra corequisite course. Dr. Gilbert (former Pre-Calculus course coordinator) and Dr. Stevens (department chair) worked together to develop the syllabus and curriculum for approval by GSU's curriculum office. This work provided the foundation for the substantive structural changes and development of the support course carried out by Dr. Washington and the team of College Algebra instructors. As previously mentioned, Dr. Washington was hired as one of the directors of the Mathematics Support Center, and she was also tasked with spearheading the change initiative around College Algebra; she was hired as a course coordinator of the College Algebra courses. Dr. Gilbert expressed general excitement about having Dr. Washington join the team, noting that it was great "having people in higher [education] looking at what we're doing more critically." Dr. Gilbert was excited that another mathematics educator was joining her in thinking deeply about the ways to effectively engage and support students in lower division mathematics courses.

In this section, I introduce the key *people* involved in the department's implementation of the support course to the College Algebra course. I highlight their past experiences with corequisites and discuss their perceptions and characterizations of the support course at GSU. I then identify the major *symbols* (the team's values) that governed the work done by the College Algebra instructional team during the Fall 2020 semester. I conclude this section with a discussion on how *power* and power dynamics was realized within the instructional team in their pursuit of creating an effective and coordinated College Algebra course.

People

Several key people contributed to the establishment of the College Algebra support course at GSU. As described earlier, the impetus for the change initiative came from the Chancellor's office of the university system. In response to this call for change, the upper administration (GSU's president, academic deans, and staff involved with course schedules and placements) collaborated with Dr. Stevens (chair of the mathematics department) to determine how GSU could be in compliance with the executive order. Then, Dr. Stevens and Dr. Gilbert (former course coordinator for the Pre-Calculus courses) devised a plan to restructure the College Algebra and Pre-Calculus courses to better support students and to stay in compliance with the mandate. Their goal was to ensure that any changes to the course structures would maintain vertical and horizontal alignment between the mathematics courses and the engineering courses that students may eventually take. In other words, any changes to the College Algebra course would coincide with the needs and expectations of students enrolled in the subsequent course (Pre-Calculus). Since all College Algebra students at GSU are assumed to be STEM majors, these changes to the gateway mathematics courses would then help prepare them for their subsequent STEM courses.

In hiring Dr. Washington, GSU gained a course coordinator to think deeply about the impact the executive order had on GSU's student body and faculty. Her goals were to continue developing the College Algebra lecture and support courses, maintain relationships with the Pre-Calculus coordinator to ensure vertical alignment of course materials, advocate for the College Algebra faculty and students, and to ensure that the College Algebra courses were running productively and efficiently. To carry out these goals, Dr. Washington created a community of instructional leaders united around the shared *symbol* of preparing students for their future

STEM courses and providing additional support for those students who were placed in the corequisite. The first semester post-executive order was tumultuous; there were issues with placement, cheating scandals, and it ultimately concluded with a high DFW rate (40%). The team of instructional leaders (including Dr. Washington, Ms. Addison, Ms. Johnson, and Ms. Martinez) united under the mission of preparing students for their future STEM courses, after recognizing the need for change in how they were delivering the College Algebra course.

Ms. Johnson had the most experience teaching the lecture course at GSU. She was the primary instructor of the College Algebra lecture prior to the executive order. Like Dr. Washington, Ms. Addison and Ms. Martinez joined the team of College Algebra instructors during the first semester post-executive order (Fall 2018). Dr. Washington was both the course coordinator for the College Algebra courses and at times was one of the instructors of the course. This group of mathematics instructors worked together towards developing the course for four semesters prior to the Fall 2020 semester.

The Fall 2020 semester was GSU's first full semester of virtual learning. And with this iteration of the College Algebra lecture and support courses came added human resources. Ms. Rose joined the team of instructors. In addition, Dr. Washington and Dr. Gilbert (former Pre-Calculus course coordinator) recruited a team of undergraduate students to work as learning assistants (ULA) for the College Algebra lecture and support courses. This meant that the instructors would have added assistance in and out of the virtual classroom. Hence the instructional leader team of College Algebra instructors during the Fall 2020 semester consisted of the instructors of the course (Ms. Addison, Ms. Johnson, Ms. Martinez, and Ms. Rose), the course coordinator (Dr. Washington), and the ULAs.

Symbols

Prior to the Fall 2018 semester, enrollment in the College Algebra was low and only required GSU to offer a single section. STEM-intending students began their academic journey in the Pre-Calculus course. After the executive order was in effect the enrollment in the College Algebra greatly increased and it required GSU to offer as many as eight sections of the course. In addition, students were placed into six sections of the support course during the first semester of implementation. This meant that more instructors were needed for these courses, and Ms. Johnson was no longer the single College Algebra instructor at GSU. The addition of more individuals to the College Algebra instructor team at GSU meant that more *people* with individual thoughts and ideas about pedagogy and classroom management were now involved in making decisions about course delivery.

In this section I begin by discussing the instructors' beliefs regarding the corequisite model. These beliefs (personal *symbols*) would ultimately affect their instructional practices and how they oriented themselves (i.e., how they taught or evaluated the course) towards the corequisite course, and I elaborate on how these beliefs were enacted in corequisite classrooms. After four iterations of the corequisite course, the instructors' perspectives on the implementation of corequisites at GSU became more aligned around the ideas of academic support that incorporated active and collaborative learning and activities around developing better metacognitive skills. I complete this section by describing these new shared *symbols* that manifested out of the evolution of the corequisite model at GSU.

Individual Beliefs – Prior Conceptions of Corequisites

Ms. Johnson, who was the sole College Algebra instructor during the academic year prior to the adoption of the model, was confused about the way that GSU implemented the corequisite model. She explained,

> My vision when they first said we're going to do remediation within the classes ... my brain didn't see it as a separate class. You know my brain saw it as, oh we identify a student in the course that seems to be struggling and we provide resources for them, rather than them being placed in another course.

The idea of having a separate support course to the College Algebra lecture did not align with Ms. Johnson's beliefs about how students should be provided academic support. She assumed that the added student support would be in the form of providing students with additional resources (e.g., extra practice examples and instructional materials). During the first semester post-executive order, Ms. Johnson was assigned a corequisite course for College Algebra and a general education mathematics course. In the general education course, she simply provided students with assistance with homework assignments during the corequisite hours. She facilitated the College Algebra support course in a similar manner, where she also incorporated worksheets and computer-based modules for extra practice.

Ms. Martinez and Ms. Rose had corequisite experiences outside of GSU. They both were adjunct faculty at local community colleges. Ms. Martinez's experience with corequisite courses at her community college was different from the way GSU implemented their corequisites. Her community college took a cohort approach where all students needing additional support were grouped together. In her classes, she entwined the academic support into the lecture material, so that the students did not know the difference between the course content and the support material. She valued this style of corequisites so much that she incorporated these experiences into her Spring 2019 iteration of the corequisite at GSU, where she included more group activities and group presentations. Because of her experience with entwining lecture and support material in the corequisite course at the community college, she always pushed for seamless delivery of course content. She would use student presentations to directly connect the activity to the lecture material. She emphasized, "if we didn't have time for presentations, I made sure that we always wrapped up with what was the whole purpose of today's activity." She continued, "so that's always important for me just to make sure that the point was getting across to the students." Ms. Martinez's Spring 2019 iteration of the corequisite is somewhat like the iteration observed during this study (Fall 2020).

Ms. Rose's community college experience with corequisites also closely resembles the more recent iterations at GSU. She explained,

> I teach the equivalent course at the community college … It sounds very much the same. And I do, you know, study skills with them. I would take them to the math center because a lot of them don't even know the resources that they have. So, we always would go on a field trip.

Ms. Rose perceived corequisite support courses as opportunities for metacognitive skill development for incoming students. She used her time in the corequisite course (at the community college) to provide students with the "soft skills" that would help them be successful long after her course. In addition, she introduced students to the campus resources that were available to them, and she provided them with additional support in developing study skills.

Enacted Beliefs – Linking Prior Conceptions to Present Thought

Learning about each instructor's values and experience with corequisites was important in understanding how they characterized the College Algebra support course at GSU. Ms. Martinez's and Ms. Rose's experience with corequisites at other institutions shaped their perception of what the corequisite course at GSU should look like. Their perceptions aligned with Dr. Washington's characterization of the support course, as a place for "students who are at risk, to have the opportunity to take time to reflect on their study practices and study habits, and also practice content." Dr. Washington recognized the value of having additional practice, like what was offered in Ms. Johnson's Fall 2018 iteration of the corequisite, but she also positioned metacognitive skill development as something that should also be incorporated into the corequisite design.

Ms. Addison, who taught the support course each semester since it was first introduced at GSU, perceived the support course as a place where students reviewed lecture material and learned study skills techniques. She explained,

> So, we [instruct] them how to write [their] notes … Just one day on it, and then how to set up the formula sheets. What's the most effective way to study? So, we'll do a little bit of those kinds of … how to check if your answer is right or wrong? How do you know if you're on the right track? Like could you write out the steps, or why you do all of the like … the reasoning behind every step of a problem.

Ms. Addison talked about how in the most recent iterations she pushed to incorporate more metacognitive work in order for students to think more deeply, make plans about problem solving, and to look over past assessments to learn from their mistakes. She explained that this was not always the case. In the first few iterations of the corequisite, she (as well as Ms. Johnson) would simply give students extra practice problems and provide them with formula sheets. Now she pushes for her corequisite students to co-construct formula sheets and to work more collaboratively in understanding the course material. Like Ms. Martinez, she valued students working in groups. This point was emphasized when she shared,

> I like that there is time to work with the students in smaller groups. And to really make the students present so you can see what they're thinking. And they can talk out what they're thinking with other people and with the whole class. So that is what I think has been awesome.

Ms. Addison was not constrained by the same time pressures in the support course as she and other instructors experienced in the lecture course. Thus, she was able to incorporate metacognitive activities, more content practice through collaborative learning, as well as preparation for and/or review of lecture content during the weekly 150 minutes (three 50-minute sessions) of the support course.

New Symbols

Addressing the changes that needed to be made in response to the executive order required connecting with the College Algebra instructors and ensuring that they were unified in their approach to corequisites. Dr. Washington established and led weekly coordination meetings among the instructors to accomplish this task. The coordination of the College Algebra courses is another institutional *structure* that resulted from the executive order. This structure was the product of hiring of the course coordinator (Dr. Washington) for the College Algebra course. The dedication and uncompensated work towards this coordination effort among the instructional team (excluding the ULAs) is one of the most prominent *symbols* that arose from the executive order. To be clear, while Dr. Washington did get three units of release time to do the work of coordination, the instructors were compensated solely on their units of instruction. Similarly, the corequisite instructor was only compensated for a fraction of the corequisite meeting time (1.3 units as opposed to 3 units). It was at the coordination meetings where other team norms and values (*symbols*) were negotiated and re-negotiated.

Coordinated Classes. Having coordination among all the lecture course sections was a critical first step in supporting students in corequisite courses. GSU took a comingled approach to corequisites, meaning that corequisite students were simultaneously enrolled in any of the lecture courses with their non-corequisite classmates. In other words, in the Fall 2020 semester there were eight course sections of College Algebra lecture and one section of the corequisite. Thus, the corequisite students were simultaneously enrolled in any of the eight lecture sections – they were not enrolled in a single lecture section together. Therefore, having coordinated classes would ensure that all corequisite students were learning the same content and (ideally) having a comparable lecture experience.

During the weekly coordination meetings, Dr. Washington solicited feedback from the instructors on course activities and assessments. Through these weekly meetings, the College Algebra coordinator and instructors became more aligned about what was going on in the lecture and support courses. Ms. Martinez described the coordination meetings as follows:

> We would meet every week and we would talk about … what's going in your [support] courses? What's going on in your lecture? We would talk about both of them. And then, we would recognize some of the students that were in our support course and our lectures, because I would say, 'oh, I have … this name in my lecture,' and then Ms. Addison or Ms. Johnson would say, 'oh, I have them in my support. Okay, so how are they doing?'

Since a student enrolled in a support course may have a different instructor for their lecture course, Ms. Martinez found the coordination meetings valuable for learning about how her students were doing in both the lecture and support courses.

The different sections of the College Algebra course became more coordinated under Dr. Washington's direction. For one, she created a team Google drive and Canvas sandbox for the instructors to share course materials. The team Google drive was a cloud-based folder where multiple people could upload and share documents. The Canvas sandbox was an empty course shell on GSU's learning management system, where instructors demoed course materials before publishing it to their own course page. In addition, the instructors added each other to their own class Canvas page in the role of teaching assistant or instructor. Thus, everyone had access to everyone else's Canvas page.

Assessments and activities for the lecture course would be posted to either the Canvas sandbox or the Google drive. Each instructor would contribute to the development of the shared class activities and assessments by suggesting, removing, or proofing questions. There were several times when instructors would suggest alternate platforms for activity deployment (e.g., Google JamBoard vs. Google Docs) depending on their familiarity with the platform or their perceptions on whether students would be able to effectively engage with it. These suggestions were always considered regardless of who brought it to the team. After activities and assessments were deployed, Dr. Washington would upload all student work onto a shared grading platform. Then, each instructor would share the grading responsibilities by choosing a specific question to grade and sharing their grading rubrics with the team. Thus, each instructor was responsible for grading a set of questions for all College Algebra students. In other words, each instructor was responsible for assessing everyone's students.

The College Algebra courses became more coordinated around pacing as well. The coordination meetings helped the group with pacing of course content. At the start of each meeting an instructor would usually ask where the other instructors left off during their lectures that day. This information allowed the instructors to stay within the same timeline for course delivery or make changes in response to what was happening within the classrooms. For instance, if students were not responding well to a particular topic, it would signal to the team that more time may need to be allocated for that topic. This would trigger a shift in the course delivery schedule, and it potentially would spark conversations about future coverage of the topic. This information was also important for Dr. Washington as she was responsible for creating initial drafts of upcoming assessments and class activities.

These sections were also coordinated through the sharing of instructional ideas and materials. For instance, Ms. Addison often found innovative ways (e.g., Desmos' Marbleslides) to present lecture content in both her lecture and support courses. She would often share these ideas with the instructional team during coordination meetings, and many times other team members would adapt them to their lecture presentations. Ms. Addison also would share her lesson notes with the whole team and welcomed feedback from the other instructors. Ms.

Johnson and Ms. Martinez found these notes helpful since they were simultaneously teaching many other courses (in and outside of GSU), and it relieved them of some course preparation time. Ms. Rose, on the other hand, chose to use her own notes. She explained,

> My lecture notes are a little bit different than the other ones, because my lecture notes are not just problems oriented. I also give them a little bit of background information, you know, kind of more of a complete set of lecture notes. And we go through that, and I do have lots of examples.

Ms. Rose felt that the lecture notes used by the other instructors were tied too close to problem solving, while hers were laced with contextual details around the course content. Thus, while the courses were coordinated around most course structures (e.g., pacing and assessments), instructors still had agency in their delivery of the material.

Collaborative Learning. Another symbol that was echoed about the support course, and about the lecture course to a lesser extent, is that collaborative learning is an important and valuable experience in which students should engage. The incorporation of ULAs helped proliferate active learning in the lecture and support courses because now each course had additional instructional leaders to support collaborative learning activities and to field student questions. The first iteration of the support course did not feature as much collaborative learning activities as the more recent iterations. Over time, more of the instructors began to see value in these types of activities in the support course. Three of the instructors (Ms. Addison, Ms. Martinez, and Ms. Rose) had prior experience with incorporating collaborative activities within the classroom.

Ms. Martinez and Ms. Addison were in support of collaborative learning opportunities in their classrooms. For instance, Ms. Martinez shared,

> In our groups, I enjoyed seeing them present and learn from each other. I learned from them. Like, what techniques can I approach in the next class that are going to be useful? So, this is mostly the way that I think in terms of my students. I like them to present. I like them to shine in their own way and then I could see, okay,

> so where can I see their weaknesses? Where can I see their strengths? And definitely push them towards where they have to be when they get to that [lecture] class.

Ms. Martinez viewed collaborative learning as an opportunity for students to learn from each other, and for her to learn from them. When students presented, she could better assess their learning and scaffold instruction. Ms. Addison echoed this sentiment and cited Vygotsky's Zone of Proximal Development as a motivator of her instructional approach in both the lecture and support courses. She stated,

> The other part of my teaching … I do think it shouldn't just be straight lecture. I think there needs to be interaction. And I think they need to practice it without me talking, because of the zone of proximal, forgot what the D stands for.

Ms. Rose, who at the time of this study never taught the support course at GSU, did not feel the same way about collaborative learning in the lecture course. She explained,

> I don't do a lot of breakout rooms … I started at the beginning of the semester and they just aren't thriving in the breakout rooms ... I always try to read my classes to see what works best for them. And some do work good in breakout rooms, but my classes tend to be the type that are just like 'lecture to me.' Like, 'let me pay attention and work out problems.' Give them some time to work out the problem and then go over the answer. That is working the best for them.

Ms. Rose felt that her students preferred straight lecture over entwining collaborative learning activities within the lecture. For this reason, she resisted putting students in breakout rooms in her lecture course. Her explanation of how she facilitated her support courses at the community college with active and metacognitive activities suggests that she is not completely opposed to collaborative learning. Perhaps the virtual nature of the College Algebra course during the Fall 2020 semester and/or the fact that she was teaching the lecture and not the corequisite course is why she was not a fan of the collaborative learning activities during this semester.

Ms. Johnson, who was a self-described traditional instructor, did not have much experience with collaborative learning but recognized the value of these activities in preparing students for their subsequent courses. She elaborated,

> [The course] helps prepare them … for learning to work in groups, because when they get to Pre-Calc they're doing activity work as well. So, it helps them in not just the mathematical concept, but like the group dynamics and stuff, which they're going to get at least through Calc III. So really, because they're gonna have breakout groups in all of those courses. So, I think it gives them a feel for already being in that environment.

She believed that through these activities in the support course, students would be better positioned to participate in the calculus sequence. Ms. Johnson only taught the support course during the first semester of implementation. She presumed that the reason why she was not assigned to teach the course since that semester was "because other people do it much better than [she did]." She explained,

> For me, it was just, it wasn't the program. It was me. Because I'm not … I wasn't used to doing like the activity-based courses and stuff … So, it took me some adjusting. And so, at first it was kind of rough at first, and then I settled in.

So, while Ms. Johnson did see value in active and collaborative learning, she acknowledged that she had not received sufficient training in productively incorporating them in her classroom. Dr. Washington also acknowledged this issue among all the College Algebra instructors and had been pushing for professional development for them. Dr. Washington was able to secure funding for a series of professional development for these instructors to occur during a future semester.

Study Skills in the Corequisite. The final symbol that arose out of the evolution of the corequisite support course at GSU was the incorporation of metacognitive and study-skills activities into the support course curriculum. These activities started appearing in the support course during the Fall 2019 semester, which was the beginning of the second academic year of implementation of the corequisite model at GSU. This updated support curriculum included guided tutorials on taking notes, weekly study journals and activities, and assessment analyses. These activities pushed students to reflect on their current practices and to determine ways they can improve upon them. In particular, the assessment analyses were metacognitive activities where students reviewed a recent test or quiz, identified their mistakes and thought about ways they could have avoided them, and created strategies for overcoming their self-identified obstacles in the future.

This change towards more metacognitive activities also coincided with an increase in student pass rates (C or higher) for corequisite students as depicted in Figure 4.4. It is worth noting that the student pass rates also increased for the non-corequisite students during that semester. However, the difference in pass rates between the corequisite and non-corequisite students was much smaller during the Fall 2019 semester than previous semesters. There may have been additional factors that contributed to the changes in student outcomes in the College Algebra course, yet the instructional team identified the addition of study skills activities as an important element in supporting students. Like Ms. Addison mentioned,

> I think it's been really good for them … to have their homework done when somebody can help them and is right next to them. I think time management is also something that's hard for the students. I don't know if it's just students in general, you know, their first year college but I noticed … that like, what's good for them is not necessarily what they will do, even though they know it's good for them. So, the requirement I think helps them.

In other words, Ms. Addison believed that the corequisite course was helpful in getting students acclimated to college work. The support course served as an opportunity for students to develop better executive functioning. The course required students to plan, to manage their time, and to leverage their time with their corequisite instructor and peers to get their work done and have emergent questions answered.

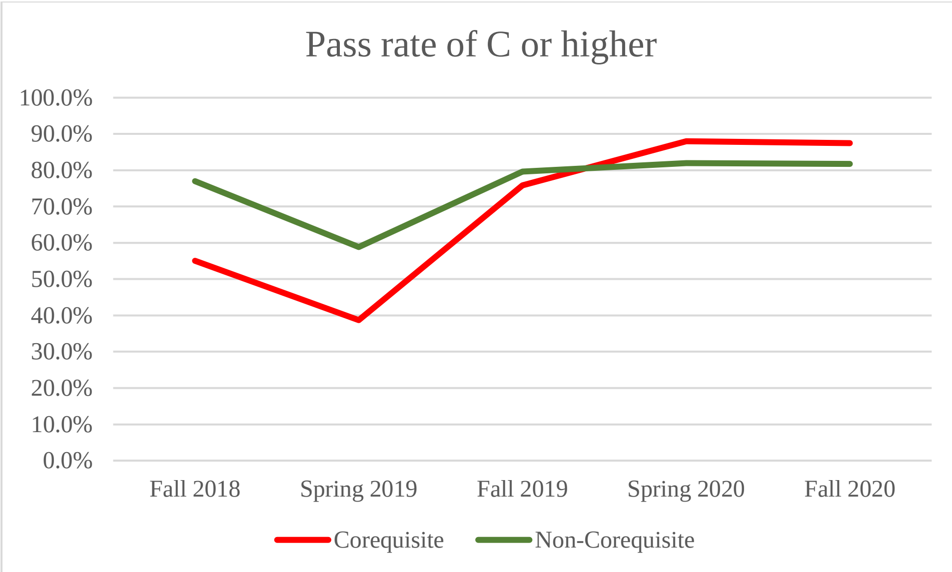

Figure 4.4. Pass rates of C or better from Fall 2018 to Fall 2020.

After the first year of adopting the corequisite model at GSU, Dr. Washington recognized that just providing corequisite students with additional practice in the corequisite course was not enough. These students were described by many of the instructional leaders as students who had a bad relationship with mathematics, routinely made nuisance errors during problem solving, and/or students that tended to memorize formulas without understanding why they were using them. The goal of the study skills activities in the corequisite course was to get students to slow down and think more deeply about what they were learning and to plan out their activity. As Ms. Martinez explained,

> So, it was more like okay let's start thinking about the question, not just like okay here is x plus seven equals 20 go ahead and solve it. No. It was like, okay, let's just think about it. Let's get ideas. Let's share our ideas. Let's see how can we tackle the problem.

While the corequisite instructors did want the students to be able to solve the problems, they also wanted the students to think more deeply about the problem before attempting to solve it. For example, during the third day of observing the lecture and support courses, students were learning about solving quadratic equations. Figure 4.5 contains a screenshot of the guided lecture notes that were presented that day, where the students were following along with the instructor as she used the *completing-the-square* technique to solve quadratic equations.

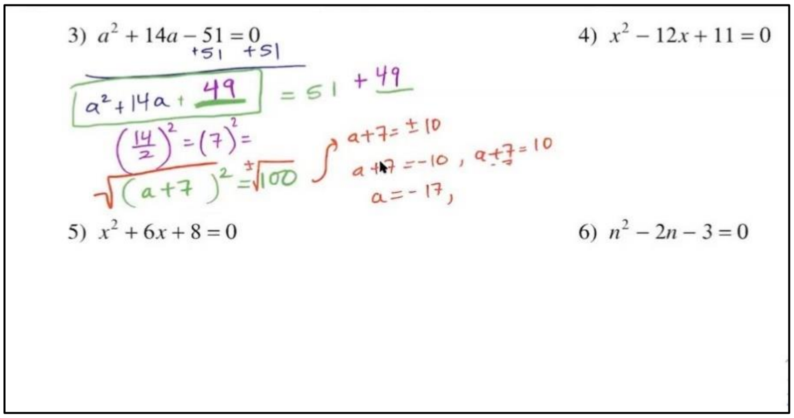

Figure 4.5. Guided lecture notes from Day 3 of observations.

Earlier that same day, the corequisite students worked in groups on similar activities. Figure 4.6 shows the first part of an activity where students were asked to substitute different values for the c-term of a quadratic polynomial and to reason about the different potential factors of the respective quadratic polynomial. The students were again asked to do a similar analysis for the second problem. The lecture activity in Figure 4.5 was focused primarily on solving equations whereas the purpose of the corequisite activity in Figure 4.6 was for students to think deeply about the relationship between the terms in the polynomials and the resulting factors. So, the corequisite activities involved more inquiry and metacognitive work, while the lecture course tasks were more procedural in nature.

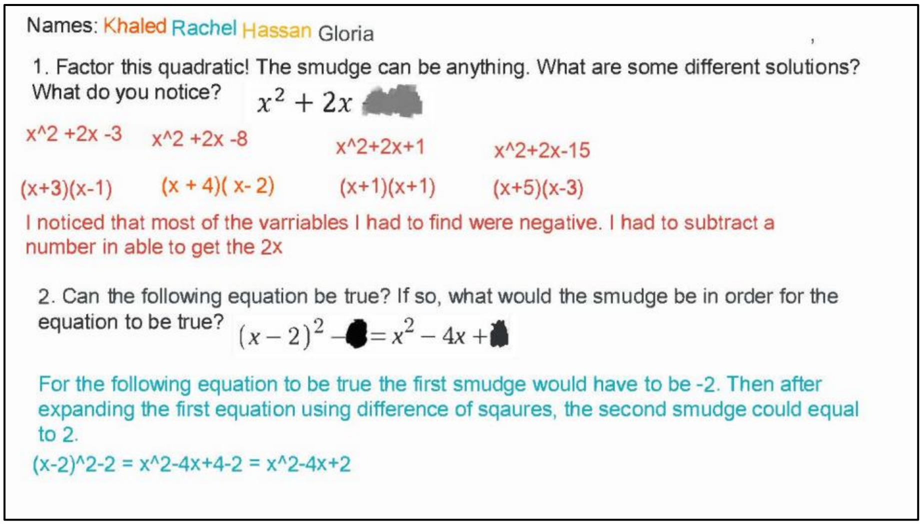

Figure 4.6. Group activity from Day 3 of observations.

Power

Earlier I highlighted the key *people* that influenced the implementation of the corequisite support course at GSU. These people include the chair of the mathematics department (Dr. Stevens), the Pre-Calculus course coordinator (Dr. Gilbert), the College Algebra course coordinator (Dr. Washington), the College Algebra instructors (Ms. Addison, Ms. Johnson, Ms. Martinez, and Ms. Rose), and the undergraduate learning assistants (ULAs). Each of these stakeholders had their own vision and/or understanding of what the corequisite model was and should look like at GSU. As outlined in the Symbols section, even with these individual perceptions of the model, the instructional team was able to coalesce around the *symbols* of coordination, collaborative learning, and providing study skills for corequisite students. In this section, I discuss how power was distributed among the instructional team, and how power dynamics played out within the instructional team.

Dr. Stevens' and Dr. Gilbert's influence on the support course was mostly in helping establish the course at GSU. For example, Dr. Gilbert created the initial syllabus for the corequisite course to be approved by GSU's curriculum committee. After the corequisite course was approved by the curriculum office and Dr. Washington was hired, Dr. Gilbert did not contribute to its development – subsequent interactions with Dr. Gilbert mainly consisted of periodic meetings regarding vertical alignment of course content between the College Algebra lecture course and the Pre-Calculus course. As the chair of the mathematics department, Dr. Stevens was naturally positioned as an authority within the team of individuals invested in the success of the College Algebra course. Nevertheless Dr. Stevens declared,

> I have to delegate, and I have a tremendous amount of trust in Dr. Washington. And so, I gave her the job of running that program and you know, doing the assessment of how students are doing in the [support course] and whether it's serving their needs.

Dr. Stevens relinquished his power over the functioning of the College Algebra lecture and support course to Dr. Washington. Though she did consult him for administrative aspects of running the lecture and support course (e.g., placement policy), she had considerable latitude in how she designed and executed the corequisite model for the College Algebra course at GSU. Therefore, the individuals that had the most immediate effect on the structure and environment of College Algebra lecture and support courses were Dr. Washington (the course coordinator), the College Algebra instructors, and the ULAs.

The Coordinator – Dr. Washington

As described earlier, Dr. Washington collaborated with the College Algebra instructors during weekly coordination meetings to discuss the flow and delivery of course content, make changes to assessments and activities, divide grading responsibilities, and to make general instructional decisions based on what was happening within the classroom. To that end, all instructional leaders had some role in running the College Algebra machine at GSU. Dr. Washington would open the weekly meetings for instructors to reflect on the efficacy of the course delivery, solicit and provide feedback to each other, and to critique the curriculum and curriculum materials. Even with this collaborative effort and division of labor, there were clear power dynamics that influenced how each member of the instructional team interacted. As the person who primarily put together the course materials and organized the weekly coordination meetings, Dr. Washington was an authority over the group.

Many of the symbolic changes to the College Algebra lecture and support course, including assessment decisions and the incorporation of metacognitive and collaborative activities in the support course, were recommended by Dr. Washington based on her research and pedagogical experiences. Dr. Washington initially experienced some resistance to some of the new pedagogical ideas that she brought to the team. She described,

> I think that the hard part is getting the instructors to shift their mindset, because of the culture they've been in. That's really hard and so, for example, when I moved away from the timed exams, they had a hard time with it … at least [Ms. Addison] and [Ms. Martinez] did. They had a hard time with that because they were like well, then we don't know if the students are learning. They're not demonstrating their learning; they could be cheating.

This example reflected the tension between the individual pedagogical values (*personal symbols*) of the instructors and the corequisite vision of the course coordinator. In response to the global pandemic, Dr. Washington made the executive decision to move away from timed exams. This was a move that she was interested in pursuing prior to the pandemic. It was her belief that performance on these types of exams was only one way of demonstrating student learning. Ms. Addison and Ms. Martinez, like many other mathematics educators, could not picture a mathematics classroom without these structures. Dr. Washington replaced the exams with individual quizzes, homework, group activities, and group quizzes. Ms. Rose silently resisted this move and elaborated in her interview,

> I think with the [lecture course], doing the group work is good, and doing the individual exams is good because some students do not like working with groups. So, you cannot have a class that's all group oriented because I have some students

> that will say, like, I don't want to work in a group. It's just their nature. They don't want to.

Her resistance was not based on measuring student learning, but rather a worry that her students would not feel comfortable working in groups. To her, forcing students to do group activities and group assessments was not fair to those students who preferred to work independently. Dr. Washington acknowledged these types of situations, as well as instances where students needed additional time and accommodations on assessments – especially but not limited to students with dis/abilities. She tried to be flexible including allowing students to abstain from group activities and assessments, and to complete them individually. Interestingly, after the first couple of group activities, many of those students that initially opted to work independently transitioned to working with their peers; this included Ms. Rose's students.

The Lead Instructors

The weekly coordination meetings ensured alignment on content and delivery among the instructors and the coordinator. At the time of data collection for this study, Ms. Addison and Ms. Johnson had taught the College Algebra lecture course every semester since the executive order was in effect. Further Ms. Addison also taught the corequisite support course each semester. Because of this, Ms. Addison, Ms. Johnson, and Dr. Washington developed a relationship over the semesters. Given the nature of their relationship, this trio regularly communicated with each other through email and through mobile messaging. Communication with the other instructors however, occurred primarily through coordination emails.

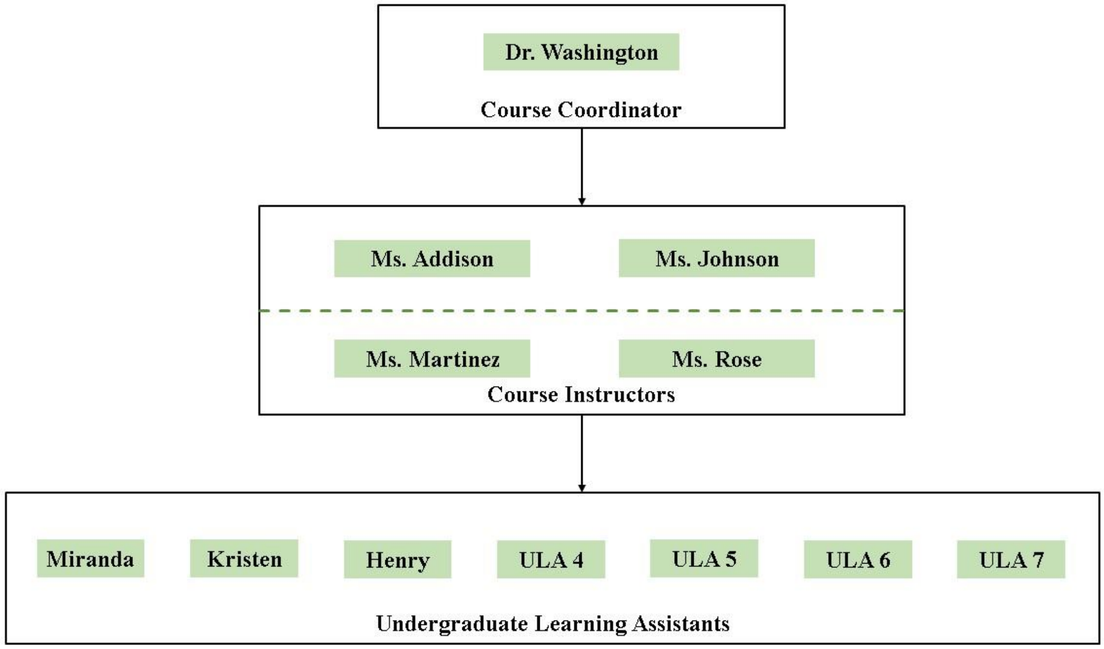

Figure 4.7. Hierarchical structure among the instructional leaders.

There was an unspoken hierarchy among the College Algebra instructors, with Ms. Addison and Ms. Johnson slightly higher than the other two instructors (see Figure 4.7); I labeled them lead instructors out of the group. Given their experience and seniority within GSU's mathematics department, Ms. Addison and Ms. Johnson had priority in class assignments and were assigned more sections of the College Algebra lecture course. These two instructors were the only instructors that were assigned College Algebra every semester since the Fall 2018 semester. In addition, Ms. Addison was assigned the single section of the corequisite during the Fall 2020 semester.

Though there was collaboration among the instructors in the coordination meetings, undoubtedly organizational decisions would revolve around these instructors given the larger share of College Algebra students that they had. For instance, earlier in the semester Ms. Addison and Ms. Johnson completed lecturing on a content section as outlined in the shared course timeline. Conversely, Ms. Martinez and Ms. Rose hadn't finished covering the material. This discrepancy affected whether Dr. Washington would include that relevant content on the upcoming group quiz. Instead of moving that material to the next assessment, the instructors discussed and agreed to keep with the pace of Ms. Addison and Ms. Johnson's classes. Ms. Rose and Ms. Martinez would then cover the relevant material during the upcoming class in order to prepare students for those questions on the group quiz. Consequently, Ms. Addison's and Ms. Johnson's students had one more instructional day to practice and ask questions about the specific topic whereas Ms. Rose's and Ms. Martinez's students were just getting exposed to the material.

Another example of this implicit hierarchy among the instructors can be seen with regards to the incorporation of ULAs in the College Algebra course. ULAs were piloted in a limited capacity during the Fall 2019 semester. Ms. Addison was the only instructor that expressed interest in continuing this program. ULAs were then incorporated into the Summer 2020 iteration of the College Algebra course. Ms. Addison's support for incorporating ULAs grew during that experience, and she then shared insights about this experience with Ms. Johnson. Thus, the move to formally incorporate them in the College Algebra course during the Fall 2020 semester was based primarily on Dr. Washington's beliefs about the potential benefits of having ULAs and Ms. Addison's stated interest in keeping them.

The Corequisite Instructor

Ms. Addison was not only a lead instructor for the College Algebra lecture but also for the corequisite support course given her extensive experience at GSU. The Fall 2020 iteration of the support course was developed by Ms. Addison and Dr. Washington over many semesters. As previously discussed, the initial iteration mainly involved students working on practice problems on worksheets or mastery-based software like Pearson's MyMathLab. Dr. Washington brought in new ideas for Ms. Addison to try in the classroom, and Ms. Addison would experiment with these ideas and other ideas that she independently discovered. Ultimately, Ms. Addison made the final decisions about what to incorporate in the support course given that it aligned with the coordinated lectures.

Even during semesters where other instructors were teaching the support course besides Ms. Addison, she was still seen as the leader. Ms. Martinez mentioned, Ms. Addison has "been teaching [the support course] throughout the whole time … She definitely has more input in it then myself just because I've only tried it a year." Ms. Martinez defaulted to Ms. Addison on decisions related to the support course because she had more experience teaching that course. And as Ms. Johnson explained earlier, she perceived that Ms. Addison did a better job of facilitating the support course. Ms. Johnson credits Ms. Addison's performance not solely on her past experience teaching the course but also on her educational background. Ms. Johnson elaborated,

> [Ms. Addison] came up through the ranks where things were much more activity based. I mean I was out in schools and when I came back to GSU and got my master's I wasn't … I didn't get a masters in Math Ed, I have an applied math masters and so the transition for me has been a little harder.

Ms. Johnson contrasted her applied mathematics background with Ms. Addison's mathematics education background where Ms. Addison gained experience with a variety of pedagogical approaches. The transition to more collaborative learning that was steeped in metacognitive activities was harder for Ms. Johnson to implement. Ms. Addison, on the other hand, was more flexible in transitioning to this new type of instructional methodology and continued refining it each semester she taught the course.

Dr. Washington supported Ms. Addison in her quest to develop or find effective support mechanisms for the support course. Dr. Washington even funded Ms. Addison to attend a professional development conference for her to learn about additional study-skills and inquiry-based techniques that she could later apply in the support classroom. To further support her in implementing these new strategies, Dr. Washington created an instructor guide for Ms. Addison to use for the support course. Even so, Ms. Addison's implementation of the activities was not always successful because she was not always aware of the rationale for the activities (which was outlined in the guide). This was a point of contention for Dr. Washington, but she ultimately provided Ms. Addison the freedom to conduct the support course as she saw fit given that it aligned with the lecture course schedule.

ULAs

The undergraduate learning assistants were at the bottom of the hierarchy of College Algebra instructional leaders. Their position in Figure 4.7 reflects the limited power that they had in making decisions about the course. The group of ULAs were interviewed and hired by Dr. Gilbert (former Pre-Calculus course coordinator) and Dr. Washington during the summer prior to the Fall 2020 semester. Only one of the seven ULAs, Kristen, was solicited for interviews for this study. She was solicited because she was the only ULA for the corequisite support course. She was a ULA for Ms. Addison's and Ms. Johnson's lecture courses as well, so she was well positioned to speak about the lecture and support course experience.

Kristen admitted that she was not given clear directions about her duties for the semester. She assumed that her role as a ULA would be like the role of a teaching assistant at her high school. She described her experience as follows:

> It's different for each teacher. Professor Addison used me a lot for grading and being active in the course, but Professor Johnson was in the lecture class and she

> ... all I really did was monitor the chat room. And I was more surprised by that because she didn't have me do any grading or anything like I was expecting. So, I think what Professor Addison had me doing when I was in her lecture class and support class was more of what I was expecting.

Kristen was the ULA for both Ms. Addison's lecture and support course, as well as Ms. Johnson's lecture class. Her responsibilities in Ms. Addison's class aligned with her expectations of a ULA. She expected to be more involved in the classroom and to help the instructor with grading. Her role in Ms. Johnson's class was simply to keep attendance and to monitor the chat during the lecture class sessions.

The Fall 2020 semester was the first semester of fully incorporating ULAs into the College Algebra course. Dr. Washington piloted ULAs during the Fall 2019 semester in a limited capacity, and prior to that semester the instructors were the only instructional leaders present in the classroom. During the initial coordination meeting of the Fall 2020 semester where the instructors brainstormed ways in which the ULAs could assist in the virtual classroom, Dr. Washington cautioned the instructors about overutilizing the ULAs. Having ULAs involved in the College Algebra course was a new course *structure* that emerged during the Fall 2020 semester. Dr. Washington wanted everyone to be careful about the ULAs' time and the amount of work they were expected to carry out. At the end of that meeting, the instructional team decided that the ULAs would be responsible for monitoring the chat (like Kristen did in Ms. Johnson's class), and helping the instructor monitor the breakout rooms during group activities and group quizzes.

Ms. Johnson's ULAs engaged with the students in her classes in the manner outlined in the coordination meetings. For instance, during the third day of observing Ms. Johnson's class, a student asked a question in the chat about the nature of the final exam. Henry, a ULA for one of Ms. Johnson's lecture sections, responded immediately to the student. When questions arose that he could not answer himself, he unmuted and brought the instructor’s attention to the situation. This was not the case for all other instructors. Though a shared vision (*symbol*) was created during the coordination meeting around how ULAs would function within the courses, some instructors engaged their ULAs in other ways. Ms. Martinez allowed her ULA to present examples to the class, and Ms. Addison sought advice from her ULA about grading. Given that this was the first semester fully having ULAs in the classroom and that there was a lack of uniformity in the implementation, more work needs to be done in establishing the nature of the role of these new instructional leaders. In fact, Kristen (who was interviewed at the start of the Spring 2021 semester), mentioned that the Spring 2021 ULAs were receiving formal training. This is an indication that the change at GSU is still ongoing.

Elevating the ULAs Position within the Classroom. Ms. Martinez used her ULA, Miranda, in a similar manner as Ms. Johnson but there were a few occasions where she incorporated the ULA into the lecture discourse by asking her questions or having her present. For instance, on the first day of observations, Ms. Martinez asked Miranda to present an example of solving a quadratic equation by *completing-the-square* (see Figure 4.8). Miranda presented her example taking a unique approach, different from the approach rehearsed in Ms. Martinez’s class. Miranda paused several times to engage with the students in the class, and at each pause the instructor interjected to see if students were understanding what Miranda was sharing.

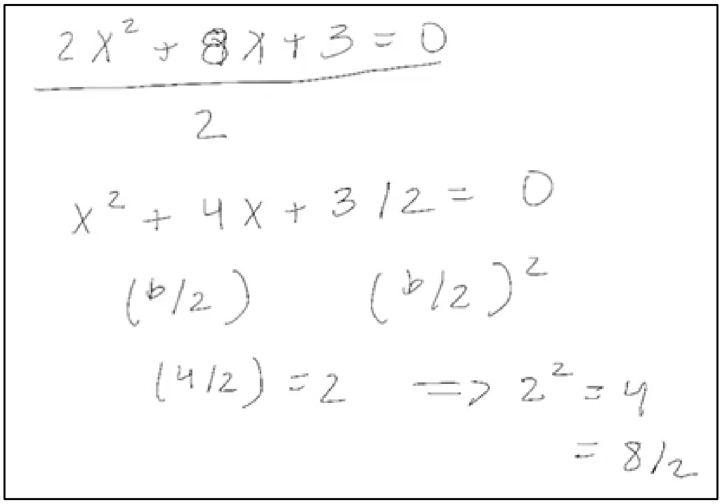

Figure 4.8. Miranda's example of completing the square.

The first time Miranda paused for student questions, Ms. Martinez interjected,

> So are you … let me, let me just pause you there. You're doing great. I just want to just say something really quickly. Um, so, so far is everybody good are you guys understanding? Do you guys have any questions? Please, by all means you can stop Miranda for a second and then just pose and just ask for questions. You guys are good.

This interruption was curious given the fact that Miranda had already paused for students to ask questions and/or determine what constant should have been added to 3/2 to get 8/2. During Ms. Martinez's interjection, nine students were posting their responses "5/2" in the chat.

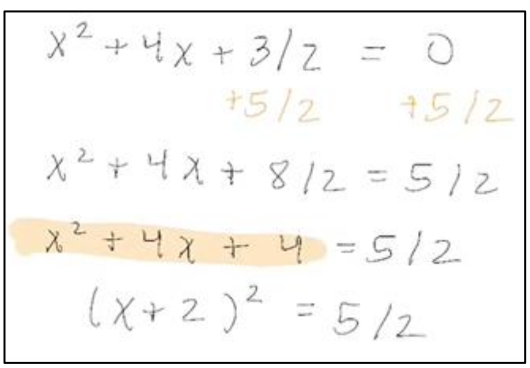

Figure 4.9. End of Miranda's example

Miranda then continued working through the problem, as seen in Figure 4.9, and once she got to the last equation displayed in the figure, she paused again for a student to finish solving.

At that point, one student (Ariana) asked whether it was the goal to get the *b*-term (the coefficient in front of the linear term of the quadratic) and the *c*-term (the constant term of the quadratic) to equal each other. Before Miranda could respond to the student Ms. Martinez interjected again,

> No. No, no, no, let me, can you stop sharing your screen Miranda for a second. Um, so we, the question was this one. The question was, if you want to have them the same. And be careful because if you look, there's going to be some examples and who asked it, I think it ... was that you Cameron?

Ms. Martinez answered the question for Miranda, presumably assuming that Miranda's example had confused the students. Allowing Miranda, a fellow undergraduate, to present in the class had the effect of positioning her as a knowledgeable person within the classroom. At the same time, interrupting Miranda during her presentation and not allowing her to address student questions potentially nullified this positioning. In the end, Miranda did not end up completing her example. After Ms. Martinez answered Ariana's question she moved onto new material. This occurrence brought into question the relationship between Miranda and Ms. Martinez, Ms. Martinez's expectations of her ULA, and the assumptions Ms. Martinez had about Miranda's mathematical abilities.

Miranda took an approach unlike the approach Ms. Martinez executed in her lectures. Ms. Martinez later acknowledged that Miranda's approach was valid when she stated,

> And that is completely valid. And however, you feel more comfortable with ... I normally just factor because when you … when we move further into vertex form, you will need that factor of *a*, so that's why I make sure that everybody understands how to factor the term instead of dividing it out. But for now, it's a legit and it's okay if we divide it out the way as Miranda does it, that's completely fair.

Ms. Martinez's tone and demeanor made it seem like Miranda's approach was either incorrect or confusing to the students. Her response to Ariana's question furthered that interpretation. Her later acknowledgement of Miranda's method and explanation of her reservations about using that method helped me, as a researcher and mathematics educator, better understand her behavior during the classroom episode. Ms. Martinez was intentional in her instruction about *completing-the-square*. She wanted students to learn how to solve the quadratic equations in a specific way so that it would be easier to make connections to quadratic functions in vertex form. Thus, while Miranda's approach to solving was valid, it did not align with Ms. Martinez's pedagogical intentions for the class. This event was potentially marginalizing for Miranda, but it is unknown how the students, or even Miranda, perceived this interaction.

The ULAs' Relationship with the Students. Based on the decisions made during the first coordination meeting, the primary role of ULAs were to monitor the Zoom chat and to assist when needed. Thus, ULAs having relationships with the students was not expected and, I would venture to say, was a missed opportunity for the instructors to learn more about their students. The ULAs were themselves undergraduate students who had previously taken the College Algebra course. Hence these students had a closer proximity to the College Algebra students and may have related more to them. Kristen reflected,

> Honestly … I wasn't as close with the students as I wanted to be … In the beginning of the semester, they have the intro and I respond to each and every intro as it had a response from either me or Professor Addison. But it was hard to kind of get that return back because they would have like a question, or they would post something, and I would respond and then that would be the end of it. I think that's more of it being online and it's hard to make that connection when you're on a screen.

Kristen's high school TAs developed relationships with the students and the students felt comfortable interacting with them and seeking help. This was not Kristen's experience as a ULA at GSU, where her engagement with students was often one-sided.

Ms. Addison recognized Kristen's dual identity as an instructional leader and as an undergraduate student. Kristen shared about times where Ms. Addison would consult her about the student experience. For instance, in one example,

> Professor Addison would talk to me about if people missed an assignment because of technical difficulties. She'd get my input as a student and then gauge what she would do off of what I know as a student and as a ULA … But sometimes it's hard, because I want to be nice to students. I want to like help them, but then I'm also like 'you messed up.' So, then, I just can't help them at all and that's really, really hard for me. And I think that's just from being a student, especially on tests when I had to give students like zero points, like I wish so hard that I could give [them] one point.

Ms. Addison valued Kristen's input based on her experience as a ULA and as an undergraduate student. She leveraged Kristen's dual identity during times of making tough decisions about student grades. While this positioning could be seen as positive because it is a clear indication that Ms. Addison sees value in Kristen's lived experience, it also shifted the burden to Kristen where she would fundamentally make assessment decisions that were at times not in favor of her fellow undergraduate peers.

A Summary in Four Frames

In the previous sections I discussed how the corequisite model was introduced and evolved during the five semesters (Fall 2018 - Fall 2020) at GSU. The cultural change came in the form of new *structures* and *symbols*, which were negotiated by various *people* within the system and mediated by the distribution of *power* between them. Table 4.2. showcases the prominent products and processes that emerged from GSU's change initiative. They represent what has changed (product) at GSU and how the relevant stakeholders went about creating this change (processes).

The most prominent *structure* that arose out of the executive order was the creation of the College Algebra corequisite course at GSU. This creation was supported through the approval of the course by GSU's curriculum committee. It was also supported through the hiring of a course coordinator who then assembled the group of College Algebra instructors into a team. It was impossible to create the corequisite course in a vacuum without considering the system in which it was part. Given logistical constraints, GSU took a comingled approach to corequisites where corequisite students were not enrolled in a single lecture course section but rather they were enrolled in any of the lecture course sections that were available. Thus, creating an effective corequisite course required that the lecture courses be coordinated to ensure that corequisite students were learning the same material though they were enrolled in different lecture sections. Thus, the course coordinator and the team of instructors coalesced around the *symbol* of coordinated classes.

Symbols represent the shared values that guide practice and decision-making within a community (Reinholz & Apkarian, 2018). There is a direct relationship between the symbols within a team and the created structures since symbols give meaning to structures. Thus, for the structural change of re-developing the College Algebra course with a corequisite support to occur, there needed to be a symbolic change. This symbolic change was the introduction of metacognitive activities for corequisite students who tended to need academic and executive functioning support. The change also came in the form of more active learning activities that allowed students to work more collaboratively in both the lecture and support courses. These changes were not enacted in the first semester (Fall 2018) of corequisite implementation. During that time, each instructor had their own beliefs about the nature of the corequisite course which led to fundamentally different classroom enactments of the corequisite course. Through many iterations of the course development the instructors and course coordinator (who at times taught the course) emerged at these new symbols upon recognizing the learning benefits. To support this change, the course coordinator funded a professional development workshop for the primary corequisite instructor (Ms. Addison) and had recently (at the time of data collection) procured funding for future professional development for all the other lecture instructors.

Table 4.2. Products and processes of cultural change towards corequisites at GSU.

	Product	Process
Structures	Re-develop the lecture course with a corequisite support course.	Hire a course coordinator; curriculum committee vet and approve corequisite course.
Symbols	Include collaborative activities in the lecture and support courses. Include metacognitive activities in the support course.	Provide funding for professional development for instructors and ULAs.
People	Develop a shared vision around College Algebra curriculum and deployment.	Create a shared folder for instructional materials; an instructor can use the shared materials or their own.
Power	Instructional leaders have input around course delivery and assessment.	Run weekly coordination meetings; instructors provide input on scheduling, class activities, and assessment materials.

The *people* frame represents the community that operates within the system. The people that directly influenced course delivery were the instructional team including the instructors, course coordinator, and undergraduate learning assistants (ULAs). These individuals had varying experiences with and conceptions of the corequisite model. Through coordination meetings the instructors and course coordinator developed a shared vision around the curriculum and the method of deployment of course activities. This was done through the sharing of instructional resources in a shared Google folder and Canvas sandbox course. Ultimately each instructor had autonomy over their own course presentation and was able to use their own instructional materials (e.g., Ms. Rose preferred to use her own lecture notes, Ms. Addison regularly incorporated her own interactive activities), while staying within the agreed upon curriculum. Any proposed changes to the curriculum were discussed during the weekly coordination meetings. Another example of instructor's autonomy was in how they engaged their ULAs. Ms. Martinez engaged her ULA through vocal discourse (e.g., classroom presentation), Ms. Addison engaged her ULA in grading, and Ms. Johnson's ULAs primarily answered student questions in the chat.

Finally, the *people* and *power* frames are related just as the *structures* and *symbols* frame are related. The *power* frame represents the relationship between the *people*, how status positions some over others, and how interactions are mediated by these power dynamics. There was an inherent power hierarchy among the instructional leaders where the course coordinator was at the top and the ULAs were at the bottom. The weekly coordination meetings functioned to mitigate these inherent tensions where the instructors were able to provide input on course schedules, activities, and assessment materials. In fact, the instructors' input was important in understanding and assessing what was going on within the classroom. Through these meetings with the main *people* involved in course delivery and assessment, relevant changes were made to the *structure* of the lecture and corequisite courses, and *symbols* and *power* were established and renegotiated. Therefore, GSU's change towards corequisites involved elements from each of the four frames, and each were important in contributing to GSU's cultural change.

Discussion

The Chancellor's office pushed GSU to make changes to their course offerings to help thwart the attrition and extended time to degree completion problem that plagued the university system. With only one academic year to make changes, the institutional leaders adopted the corequisite model and hired a mathematics educator to spearhead the change initiative. GSU's transition to the corequisite model was rocky, and the first semester of implementation of corequisites in the College Algebra course marked the highest DFW rate (40%) for that course between 2016 and 2020. The College Algebra corequisite has since evolved from that first semester through the development of new course structures and the on-boarding of more people coalesced around symbols for implementing an effective College Algebra lecture and support course. This evolution was made possible by the work of the instructional team, which was led and coordinated by Dr. Washington.

RQ 1.1 – What are the goals and beliefs of institutional stakeholders as they pertain to the corequisite model?

The corequisite model was chosen by the department chair at GSU primarily because it was the easiest model to implement within the short time frame (one year) given to them by the Chancellor's office. He, like many of the other institutional stakeholders, were unsure of the efficacy of the model at addressing GSU's DFW and placement issues. The College Algebra instructors initially had different ideas of what the model should look like. One instructor (Ms. Johnson) pictured a system where students who needed additional support were provided with support materials (e.g., extra practice problems/modules). Other instructors pictured a model where students worked collaboratively (Ms. Addison and Ms. Martinez) and received training towards developing metacognitive skills (Ms. Rose). The course coordinator pictured a support course that contained all these elements while providing just-in-time instruction. By the Fall 2020 semester, this was also the belief shared among all the instructional leaders (instructors and course coordinator). Specifically, the College Algebra corequisite course was seen as a support course for the College Algebra lecture where students engaged in collaborative and metacognitive work while receiving just-in-time remediation of lecture course content.

By the end of the Fall 2020 semester, the institutional leaders had only anecdotal evidence of the efficacy of the model. They had not performed a formal analysis of the model and its effects on student persistence outside of the course. Thus, it was hard for them to definitively say whether the corequisite course was successful. These stakeholders recognized that the corequisite course supported student learning of lecture course content. More work is needed in measuring the effect the support course had on students' experiences in their next mathematics course.

RQ 1.2 – How are institutional stakeholders working together to ensure the successful implementation of the model?

Dr. Washington facilitated weekly meetings of the College Algebra instructors to ensure that there was alignment around course delivery and assessment among all instructors. As course coordinator, she was able to influence pedagogy in the lecture and support courses. As suggested by Apkarian and Rasmussen (2017), individuals in this position can sway instructors in various ways including lending opinions and providing resources. Dr. Washington was able to create a community among the instructors, where they all had a stake in each other's courses. Each instructor had input on the course curriculum, lecture activities, and grading. The corequisite instructor, who was also a lecture instructor, based her support course activities on the course plan negotiated by all the instructors. In addition, Dr. Washington provided the corequisite instructor with pedagogical resources to incorporate into the corequisite course (e.g., study skills activities). The corequisite instructor was the main authority of the support course and had full control over the classroom environment within the support course. She ultimately integrated and/or modified many of the recommended study skills activities after discovering the effect they had on student learning; she learned this from a professional development workshop that was funded by Dr. Washington.

There were implicit power dynamics at play, where Dr. Washington was the course coordinator and was the facilitator and developer of many of the course artifacts. However, she distributed power by encouraging the instructors to edit the material she presented, make decisions on how they presented materials within their class, and contribute their own artifacts to the group. Ms. Addison regularly shared activities with the team that she found useful in the virtual classroom. Power dynamics also surfaced among the College Algebra instructors, where Ms. Addison and Ms. Johnson were the unspoken lead instructors of the course due to their seniority in the mathematics department and extensive experience teaching and developing the College Algebra course at GSU. Despite these power dynamics, the team of instructors worked collaboratively to make the best out of the virtual nature of the course during the Fall 2020 semester.

There were also explicit power dynamics that surfaced through the adoption of corequisites. On a larger scale, power dynamics were evident in the shift of placement decisions for students in lower division mathematics courses away from the institution (GSU) and towards the Chancellor's office. On a local scale and within the instructional team, explicit power dynamics were also present where the instructors were direct supervisors of the ULAs. The roles and responsibilities of the ULAs were negotiated among the course coordinator and instructors and relayed to the ULAs. While ULAs in Ms. Johnson's class monitored the Zoom chat, other ULAs were involved with grading and grading decisions (e.g., Kristen in Ms. Addison's class), and presenting within the lecture course (e.g., Miranda in Ms. Martinez's class). Beginning in the Spring 2021 semesters, these ULAs began getting formal training on their roles and responsibilities to better engage within the classrooms.

RQ 1.3 – What is the nature of the academic support available to students in corequisite courses?

Students in the support course received added practice on the lecture course content. During the Fall 2020 semester, the instructional team pushed to do more collaborative learning activities. Since the corequisite course was mainly for reviewing course material, there was ample opportunity to integrate these activities. The corequisite course also supported student learning by providing study skills training. Since it was the first semester of college for many of the students in the class, the instructional team believed that it was important for students to learn how to take notes, how to study, and how to review their past assessments. These metacognitive activities were introduced during the Fall 2019 semester, the same semester where the DFW rates for the course dramatically decreased. Thus, there is evidence that the corequisite course is helping students successfully complete their College Algebra lecture course, but more research is needed to determine if the effect is lasting. In other words, it is yet to be determined whether the skills developed in the College Algebra support course will sustain through their next mathematics course and beyond.

Chapter 5: Student Participation

In Chapter 4, I provided institutional context for corequisites at Grizzly State University (GSU). In this chapter I home in on the activity within the classrooms in order to address the second research goal of examining how opportunities to engage in course content are distributed within the corequisite course. This chapter begins with a summary of the methodological approaches used to analyze the data. Then, I present a general overview of the classroom environment in the lecture and corequisite courses. Following, I present research findings comparing student engagement in the lecture and corequisite courses. These findings aid in answering the first research sub-question: *How are opportunities to engage in course content distributed in corequisite courses vs. lecture courses?* To answer this question, I describe the venues in which students participated in the virtual classroom. I also present data around the solicitation methods employed to engage students. Finally, I compare overall trends and characteristics of student participation in the lecture course sections and the corequisite course at GSU, while highlighting instances of participation imbalance that emerged.

The second research question towards addressing the second research goal was: *How do students in corequisite courses engage in their lecture courses?* To answer this question, I compare the nature of student engagement of the subset of corequisite students observed in both their corequisite course and their lecture course. That is, 13 of the 24 students enrolled in the corequisite course were also observed in their lecture courses – I analyze the differences in their participation frequency and quality between courses. I conclude this chapter with a discussion of these findings.

Methodological Approach and Data Sources

There were four instructors teaching the College Algebra lecture course during the Fall 2020 semester at GSU – they included Ms. Addison, Ms. Johnson, Ms. Martinez, and Ms. Rose. Ms. Addison also taught the corequisite support course. Due to scheduling conflicts, all instructors were observed except for Ms. Rose's class. Observations occurred over six days, where four of the lecture sections (A1, A2, B, and C) and the single corequisite course were observed (see Figure 5.1). Lecture A1 and A2 were taught by Ms. Addison, Lecture B was taught by Ms. Martinez, and Lecture C was taught by Ms. Johnson.

For each day, the corequisite course was observed followed by two lecture sections taught by different instructors. The study was designed this way so that I could understand how related content was covered in both the lecture course and the corequisite course. The first two days of observation occurred during the fourth week of the semester, where Lectures A1 and C were observed. Days 3 and 4 of the observation occurred during the eighth week of the semester, where Lectures A2 and B were observed. The final two days of observation occurred during the twelfth week of the semester, where Lectures B and C were observed. Each classroom observation was recorded using the Zoom videoconferencing platform. Student participation was recorded in the chat, the breakout rooms, and in the main Zoom room (whole class). Copious fieldnotes were taken to capture student activity including how many students were in attendance, how many students had their video cameras on, and the number of students that participated.

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Corequisite 9-9:50am	Corequisite 9-9:50am	Corequisite 9-9:50am	Corequisite 9-9:50am	Corequisite 9-9:50am	Corequisite 9-9:50am
Lecture C 11-11:50am	Lecture C 11-11:50am	Lecture A2 11-11:50am	Lecture A2 11-11:50am	Lecture C 11-11:50am	Lecture C 11-11:50am
Lecture A1 1-1:50pm	Lecture A1 1-1:50pm	Lecture B 1-1:50pm	Lecture B 1-1:50pm	Lecture B 1-1:50pm	Lecture B 1-1:50pm

Figure 5.1. Observation Schedule.

Student verbal participation was captured through the coding of student utterances (whether vocal or in the chat) using the EQUIP observation tool. EQUIP stands for Equity Quantified In Participation, and is an observation tool used for quantifying patterns of student participation (Reinholz & Shah, 2018). The unit of analysis is a participation sequence, which is a chain of utterances between a student and an instructor, where a new sequence begins upon the entry of a new participant. Each sequence was coded along several discourse dimensions to document where the discourse occurred (e.g., breakout, chat, or whole class setting), how the student was solicited for participation (e.g., were they called on?), the types of questions the teacher posed to the student (e.g., low vs. high cognitive level), the quality of the student response (e.g., low vs. high cognitive level), the length of the student's utterances (e.g., short vs. long response), and how the teacher responded to the student's ideas (e.g., did the instructor evaluate the student's response?). Descriptive and statistical analyses (e.g., Pearson's correlation, Chi-square) are presented in this chapter. To control for potential Type 1 errors in the statistical tests, a Holm-Bonferroni correction was made for all *p* values. These analyses were used to measure how students were engaging in their College Algebra lecture and corequisite courses, the relationship between classroom engagement and final course grades, and to determine whether observed differences were by chance.

Overview of the Virtual Classroom Environments

Relationship between the Corequisite and the Lecture Courses

In Chapter 4, I discussed how initially each instructor had a different perception and expectation of what the corequisite course was supposed to be. After four iterations (from Fall 2018 to the start of this study in Fall 2020) of the corequisite course at GSU, these instructional leaders coalesced around a flavor of the corequisite model that entwined collaborative learning and study-skills with course content. The corequisite course was broadly characterized as a one-unit support course that helped prepare students for the work they would encounter in the lecture course. This characterization aligns with what I observed during the observation period. For instance, on the first day of observation, corequisite students received a preview of the lecture course material that they would cover in the lecture course later on that day.

During this observation, the students in the corequisite course worked on solving linear equations such as the one pictured in Figure 5.2. The corequisite instructor, Ms. Addison, did not automatically describe the activity as "solving a linear equation." The class worked collectively in the whole class setting to solve the puzzle by sharing a variety of strategies such as substituting the values of given shapes and canceling equivalent shapes on either side of the balance. After about 15 minutes, Ms. Addison formally introduced the mathematical language that described some of the strategies used to solve the puzzles. For example, "substituting values of given shapes" is the process of *evaluating* expressions. "Canceling equivalent shapes" was described as the process of applying the *addition property of equality* – this property states that the same quantity can be added or subtracted from both sides of an equation without affecting the equality statement. Ms. Addison concluded the class session by summarizing the activity and explaining how it related to the material they would learn later in the day during their lecture couse. She then shared a link with the class to a website with similar puzzles for the students to continue practicing at their own discretion.

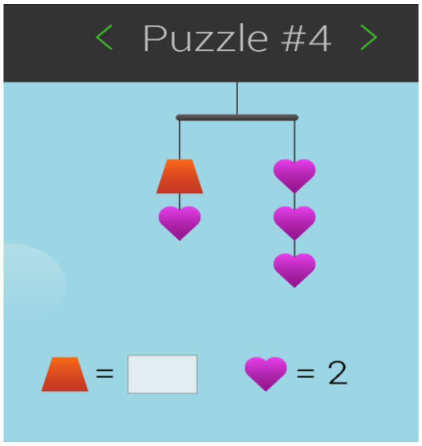

Figure 5.2. Informal model of a linear equation.

General Details about the Classrooms

Table 5.1 showcases some basic details about the five virtual classrooms observed in this study, including the number of enrolled students, the maximum daily attendance during the observation period, the total number of students that vocally participated during the observation period, and the total number of students that had their video cameras on at least once throughout the observation period. The corequisite, the Lecture A1, and the Lecture A2 courses were all taught by Ms. Addison. Lecture B was taught by Ms. Martinez, and Lecture C was taught by Ms. Johnson. All courses had the same three-day schedule – they met synchronously for 50 minutes each day, with two days of lecture (Monday and Wednesday) and one day of assessment or review (in the case of the corequisite course).

Table 5.1. Specific characteristics of the observed courses.

Course	Number of Students Enrolled	Maximum Number of Students in Attendance	Number of Student Voices Heard	Number of Student Faces Seen
Corequisite	24	24	19 (79.2%)	13 (54.2%)
Lecture A1	42	39	12 (30.8%)	28 (71.8%)
Lecture A2	49	44	19 (43.2%)	26 (59.1%)
Lecture B	33	26	24 (92.3%)	3 (11.5%)
Lecture C	47	34	16 (47.1%)	3 (8.8%)

During the observation period, student attendance was recorded by taking note of the Zoom participant list. The corequisite course was the only course to have full attendance for any of the observation days. As illustrated in Table 5.2, student attendance in the corequisite course fluctuated from observation to observation. Attendance in the corequisite was anywhere between 75% to 100%. In many of the courses, student attendance diminished as the semester went along. For instance, the observations for Lecture C occurred on the first two days and last two days of the observation period. During this time, student attendance gradually decreased from around 87% to about 70%. Towards the end of the semester Ms. Johnson, the Lecture C instructor, began sending weekly reminder emails to encourage students to attend class.

Table 5.2. Changes in student attendance throughout the observation period.

Course	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Corequisite	88%	100%	88%	96%	83%	75%
Lecture A1	93%	93%	-	-	-	-
Lecture A2	-	-	90%	90%	-	-
Lecture B	-	-	79%	79%	67%	70%
Lecture C	87%	85%	-	-	72%	70%

Encouraging student attendance and sustaining student engagement in the virtual classroom was challenging. The virtual environment created a boundary between the student, their peers, and the instructor. In this environment, it was easy for students to treat their class like a webinar and be logged into the Zoom virtual classroom without engaging with the material directly. However, the Zoom videoconferencing tool allowed for greater potential for student engagement by enabling students to share their faces, their voices, and their computer screens. Over 50% of students in each of Ms. Addison's classes (the corequisite, Lecture A1, and Lecture A2) opted to keep their videos on, though many of them in her lecture course sections chose to not vocally participate. The ability to see faces helped to humanize the online experience and foster a somewhat comparable classroom experience as the in-person setting.

In the virtual learning environment, often the only voice that could be heard is that of the instructor. From Table 5.1, we saw that all instructors were able to get some student voices involved in the virtual space. In Ms. Addison's corequisite course, all but five students vocally participated by unmuting themselves during the observation period. Similarly, a large share of Ms. Martinez's Lecture B students vocally participated throughout the observation period. In contrast, the virtual classroom in Ms. Addison's and Ms. Johnson's lecture course sections were relatively quiet where the main voices heard belonged to the instructors. Such environments tend to perpetuate the idea that the instructor is the primary authority within the classroom.

Including Undergraduate Learning Assistants

Each instructor was assigned an undergraduate learning assistant (ULA) for their course. The ULAs were undergraduate students who had previously taken the College Algebra course and demonstrated a good understanding of the course material. The instructors mainly used their learning assistants to take attendance and to help with grading. Outside of these responsibilities, Miranda (Ms. Martinez's ULA) also assisted by presenting examples in the whole class and answering candid questions from the instructor during the lecture. I infer that the amount of vocal student engagement in Ms. Martinez's class may have been a result of how she engaged with Miranda within the virtual classroom. For instance, in the following sequence, Ms. Martinez paused her lecture to ask Miranda a question about her approach to problems involving the distance formula:

Ms. Martinez:	What if we scroll down and we start applying this distance formula. And you'll notice that they have them backwards and it doesn't really matter if you want to do the *x* before the *y*. That's okay. So how would we do example one? Step one? You want to label your points. What do you mean by label your point (x_1 ,y_1), that would be your first step. Miranda, how did you usually do this when you first learned the distance formula? Can you give me your input?
Miranda:	Um, I guess just following the formula.
Ms. Martinez:	Did you know that it came from the right triangle?
Miranda:	Um I don't think when I first learned it. Probably not, but then maybe going up in the classes which I feel is like a disconnect with high school math.
Ms. Martinez:	Yeah, so it's really nice to have that relationship. Like, where does it come from, where does that square root come from, like, does it come from the air. No. And actually, it follows this geometric figure that leads us to that square root using the Pythagorean theorem.

Ms. Martinez transitioned her lecture into an informal conversation with Miranda about the origin of the distance formula. Miranda was given space to share her experience learning the distance formula, and how she did not make the connection between the formula and the right triangle until she took more math courses. This exchange was an opportunity to validate students' experiences learning the course content. As an undergraduate student who recently completed the College Algebra course, Miranda's experience may have resonated with many of the other students who never connected the distance formula to the geometry it arrives from. It may have validated a student's experience of not immediately seeing the connections between presumably distinct mathematical concepts. By Ms. Martinez providing Miranda the space to share how she approached distance problems, Miranda was positioned as a knowledgeable person. This action can have the vicarious effect of validating other students' experiences and helping them to see themselves as knowledgeable (Bandura, 1997). This act of vocally engaging the ULA, a fellow undergraduate, may have contributed to the number of student voices heard in the Lecture B course, as more students felt comfortable engaging vocally. In the next sections I will present findings using an EQUIP analysis towards understanding how the instructors engaged students in the virtual space.

Student Engagement in the Corequisite Course vs. Lecture Course Sections

In the virtual classroom, student participation was important in establishing a community of learners, or at the very least, it allowed for other voices and ideas to enter the discourse apart from the instructor. Without student engagement, the 50-minute class would be no different from a webinar or an asynchronous classroom. As it turns out, getting students to participate may have influenced course outcomes for certain groups of students. A bivariate Pearson correlation test produced a statistically significant relationship ($r(22) = .45$, $p = 0.014$) between the amount corequisite students participated in the corequisite course and their final grade in their lecture course. The p value was computed using the Holm-Bonferonni method to account for potential Type I errors as a result of the multiple statistical tests conducted. There was not a statistically significant relationship ($r(169) = .10$, $p = 0.09$) between the amount of participation in the lecture course and final course grades for the lecture students. Figure 5.3 displays the relationship between the corequisite students' participation in the corequisite course and their final lecture grade.

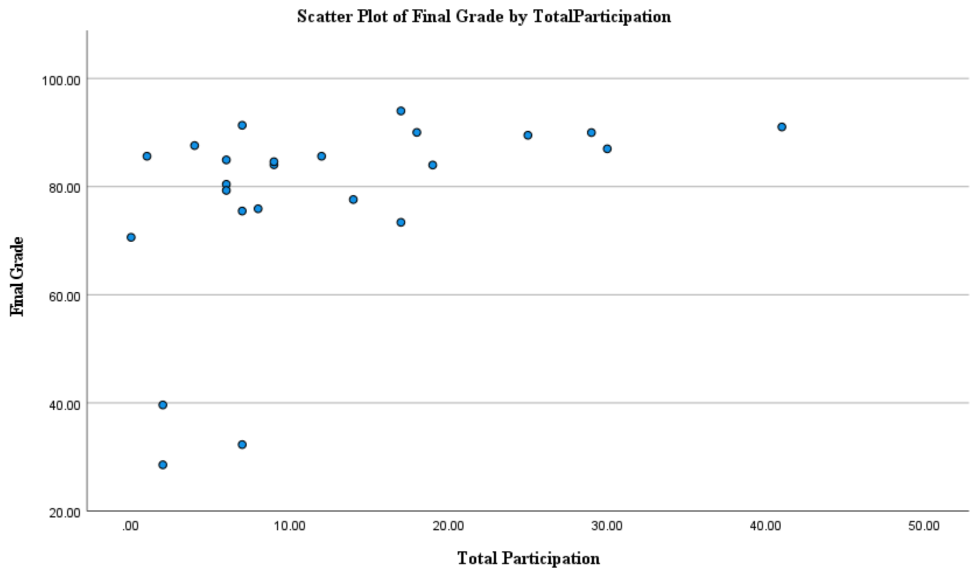

Figure 5.3. Corequisite student participation in the corequisite and their final lecture grade.

Venues in which Students Participated

With classes moving online, instructors were pushed to find different ways to interact with their students. All courses involved in this study met via Zoom, which provided multiple venues for instructors to engage with their students. The predominant method for students to verbally interact was through the main Zoom room, the chat box, and the breakout rooms. The EQUIP coding captured these distinct venues for student participation. Participation sequences coded as "Whole Class" were those that occurred in the main Zoom room where students unmuted themselves and vocally contributed to the lesson. Participation sequences coded as "Chat" were those that occurred in the main Zoom room where students shared in the public chat. Participation sequences coded as "Breakout Room" were those that occurred in the breakout rooms in which the instructor was present. Thus, student engagement in rooms where the instructor was not present were not captured nor coded. The rationale for this methodological decision was to study ways in which instructors interacted with students. Therefore, capturing the instructor-student interactions and student-student interactions in the presence of the instructor was prioritized during data collection.

Table 5.3. Venue distribution of coded student participation.

Course	Breakout Room	Chat	Whole Class
Corequisite	36.8% (t = 111 minutes)	59.6%	3.6%
Lecture A1	4.8% (t = 15 minutes)	93.8%	1.4%
Lecture A2	17.3% (t = 35 minutes)	78.1%	4.6%
Lecture B	3.5% (t = 34 minutes)	82.8%	13.7%
Lecture C	0% (t = 10 minutes)	7.0%	93.0%
Total (N = 1690)	13.0%	74.0%	13.0%

Note. N refers to the number of coded participation sequences. The t represents how long students spent in the breakout rooms during the observation period. Lecture C students worked in breakout rooms, but the instructor did not join them during the observation period.

For each course observed in this study, Table 5.3 displays the percentage of participation sequences that occurred in each of the described venues. In most classes, the chat box was the primary way that students participated; however, the predominant method of student participation in the Lecture C course was through the whole class discussions in the main Zoom room. In the corequisite course, the breakout rooms functioned as another source of substantial student engagement with 37% of the participation sequences in that class coming from that venue. Comparatively, there was a greater percentage of participation in the breakout rooms for corequisite courses than lecture courses. In fact, four out of the six observations of the corequisite course contained segments of time where students were working in the breakout rooms. For each of the lecture courses, students engaged in the breakout room only one day out of the observation period. In other words, during the observation period there were varying times spent in the breakout room for each course: corequisite students spent 111 minutes out of 300 class minutes, Lecture A1 students spent 15 minutes out 100 scheduled class minutes, Lecture

A2 students spent 35 minutes out of 100 scheduled class minutes, Lecture B students spent 34 minutes out of 200 scheduled class minutes, and Lecture C students spent 10 minutes of 200 scheduled class minutes.

Methods of Soliciting Participation

The instructors had various ways of soliciting participation in the virtual classroom. They either called on individual students or groups of students by name (Called On) or instructed all students to respond in the chat (Chat Solicitation). A sequence was coded as Not Called On when students participated without explicitly being solicited by name or group. One instance of this type of solicitation is when the instructor poses a question to the class and does not solicit participation from any particular student or group of students. Other instances of this code were when students posted ideas in the chat or unmuted themselves to participate in the whole class or breakout room without being called on by name or group.

Table 5.4. Solicitation methods in each course.

Course	Called On	Chat Solicitation	Not Called On
Corequisite	23 (7%)	38 (11%)	273 (82%)
Lecture A1	7 (2%)	162 (56%)	122 (42%)
Lecture A2	4 (1%)	159 (45%)	189 (54%)
Lecture B	73 (12%)	229 (38%)	297 (50%)
Lecture C	1 (1%)	2 (2%)	111 (97%)
Total	108 (6%)	591 (35%)	969 (57%)

As can be seen in Table 5.4, targeted solicitations (Called On) occurred less frequently than other solicitation methods. In most classes, Not Called On was the predominant way that students engaged in the class. Chat Solicitation was the second prominent method for soliciting student engagement. In all instances of this type of solicitation, the instructor mandated (e.g., for attendance purposes) or incentivized students (e.g., for extra bonus points) to participate. Typically, when an instructor requested participation via a Chat Solicitation, they asked students to respond to a low-level prompt. In these instances, students were asked to post a solution to an algebraic prompt, recall a fact, or state whether they agreed/disagreed with a mathematical idea.

Following a chat solicitation would be a flood of student responses in the chat box – all students in attendance would contribute a response during that time. In the in-person classroom, these types of instances where all students responded to such prompts in a choral manner would not typically get coded using the EQUIP observational tool. I have included these totals up until this point to help illustrate how students participated in the virtual setting. Table 5.5 shows an updated distribution of the venues from which student contributions arose after removing the chat solicitations. Even with the data reduction, chat still functioned as a major source for student engagement in most courses. This may imply that the instructors' chat solicitations helped establish the classroom norm of students sharing their ideas in the chat box. Thus, after removing the explicit chat solicitations, students continued to use that venue for participating in the virtual classroom. Students regularly engaged in the chat to pose a question or comment on a speaker's contribution, when the instructor posed open questions to the class without calling on a particular student to respond, or when the instructor called on a particular student and they did not want to or were not able to provide a vocal response.

Table 5.5. Percentage of student participation in each venue (without chat solicitations).

Course	Breakout Room	Chat	Whole Class
Corequisite	41.6%	54.4%	4%
Lecture A1	10.9%	86.0%	3.1%
Lecture A2	31.6%	65.8%	2.6%
Lecture B	5.7%	72.1%	22.2%
Lecture C	0%	5.4%	94.6%
Total	19.9%	61.1%	19.0%

From Figure 5.4, we see that the removal of participation sequences initiated from Chat Solicitations had little to no impact on the number of students that participated in the corequisite course (no difference) and the Lecture C course (difference of one student). For the other lecture courses, 10 students from Lecture A1, eight students from Lecture A2, and three students from Lecture B, disappeared from the data once the Chat Solicitations were removed. This suggests that these students only participated during the observation period to the extent that they were mandated or incentivized to do so by the instructor. In the results to follow, contributions that were initiated through Chat Solicitations will not be included in order to highlight the student contributions that were not explicitly mandated or incentivized.

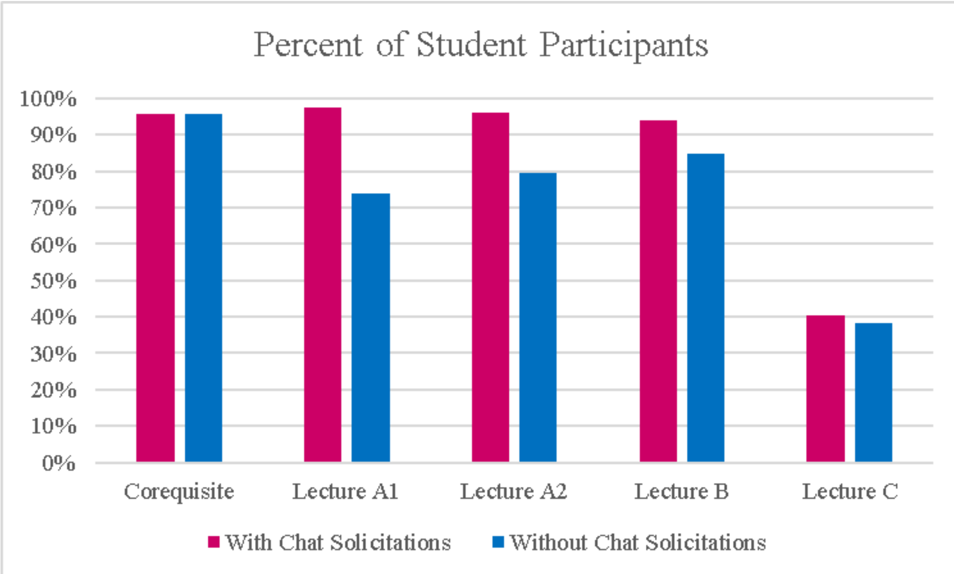

Figure 5.4. Change in the number of students that participated after excluding chat solicitations.

Participation Trends

Over the 18 observations, there were a total of 1,690 participation sequences coded – of these participation sequences, 1100 were not coded as Chat Solicitations. Accordingly, Table 5.6 displays the counts of the participation sequences (excluding the Chat Solicitation) for each observed class. Besides the Lecture C course, the corequisite course had the lowest average number of participation sequence per observation with 49 (296/6). The average for Lecture A1 was about 65 (129/2), Lecture A2 was about 97 (193/2), Lecture B was about 93 (370/4), and Lecture C was about 28 (112/4). This was not surprising since the students in the corequisite course spent more class time (total of 111 minutes out of 300 minutes) working together in breakout rooms than the other courses. Only breakout room participation sequences where the instructor was present were captured in this count.

Table 5.6. Distribution of participation sequences across the five classes.

Course	Total observations	Total sequences	Percent of students that participated	Percent of students that participated, on average, at least once per observation
Corequisite	6	296	95.8%	79%
Lecture A1	2	129	73.8%	59.5%
Lecture A2	2	193	79.6%	61.2%
Lecture B	4	370	84.8%	66.7%
Lecture C	4	112	38.3%	17%

Lastly, the percentage of students that participated in class discussions was higher for the corequisite course than any of the lecture courses. About 96% (23 out of 24) of the corequisite students contributed to the classroom discourse at least once throughout the six observations. On average, there was also a higher percentage of students participating at least once per observation in the corequisite course than in any of the lecture courses. 79% (19 out of 24) of the corequisite students contributed at least six times total – on average, this is about one time per observation. Lecture C had the least percentage of students participating throughout the observation period. As described thus far, students in this class primarily participated in the whole class setting, and those that participated were not explicitly called on to do so. Without using any other method of soliciting participation (calling on students or engaging students in the breakout room), only certain students in the Lecture C course opted to unmute and participate during the observation period.

Nature of Student Participation

Thus far we have seen that students in the lecture courses and the corequisite course relied heavily on the chat to participate in the virtual classroom. Even so, the corequisite course had a greater proportion of their student contributions coming from the breakout rooms than any other course. We have also seen that most of the participation sequences across all courses were coded as Not Called On, where students interacted in the class without being personally solicited. Since students in the corequisite course spent more time working together in the breakout rooms, many of the Not Called On solicitations were instances of student-student interaction where the instructor was less of a central figure but rather a resource for further explanation when appropriate. In the lecture courses, the Not Called On solicitations more often occurred when the instructor posed general questions to the class or when students had comments or questions during the lecture.

There were some additional similarities between the lecture courses and the corequisite course with respect to the nature of student talk. 94% of the student contributions in both types of courses were coded as “Other” and “What.” These types of contributions are relatively low-level contributions. In other words, these contributions were of lower cognitive demand which required the minimum amount of thinking. For instance, a sequence was coded as “Other” when a student asked a question or made a non-mathematical utterance. A sequence was coded as “What” when a student simply recalled a mathematical fact, read a problem statement, or provided a numerical answer without further elaboration. Similarly, the teacher solicitations in both the corequisite and the lecture courses were mostly low-level, with only 6% of teacher solicitations in the lecture courses recognized as high cognitive demand (coded as “How” and “Why”) and only 5% in the corequisite course. “How” solicitations called for students to discuss the procedure taken to approach a problem, and “Why” solicitations called for students to discuss their reasoning.

There were some noteworthy differences between lecture course sections and the corequisite course. For one, 32% of the corequisite students’ contributions were coded as “Long Response,” whereas only 4% of the lecture students’ contributions were “Long Response.”

Student contributions were coded as “Long Response” if they consisted of about 21 or more words. This finding was not unexpected given the breakdown of student contributions stated previously (in Table 5.5). Specifically, a larger share of student contributions in the lecture course sections came from the chat, where student contributions were short and succinct. In the corequisite course, students spent a larger share of their time interacting vocally, and thus, there were more opportunities to provide longer responses. Another notable difference between the two types of courses was that the corequisite instructor responded to a greater share of student contributions (33%) than most of the lecture instructors (15.1% for A1, 14.5% for A2, and 23% for B). Interestingly, the instructor for Lecture C responded to 70.5% of student contributions whenever they occurred. This was interesting because though there was less student engagement in Lecture C, Ms. Johnson (the Lecture C instructor) responded to a large share of student contributions.

Equity in Classroom Participation

In this section I discuss equity in classroom participation within each of the observed courses. I begin by describing patterns in student participation across gender identification. I then illustrate how student participation varied based on students’ declared majors. I conclude this section with a discussion about ways that instructors were inclusive and were able to shift the balance of student participation towards elevating more student voices. Absent from this section is a discussion around racial equity. Due to insufficient data around students’ racial identification, analyses based on race was not possible to pursue in this study.

Gender Equity

Though on average, women are more likely to complete a developmental education sequence (Fong et al., 2015), studies (e.g., Ernest et al., 2019; Johnson, 2007; Spencer et al.,

1999) have demonstrated that women experience internal and external resistance learning and participating in STEM. For most learners, the classroom is the main location for engaging deeply with mathematics, thus the classroom is an important venue for counteracting gender inequity that is experienced by women and girls.

Table 5.7. Gender distribution in each course.

Course	Women	Non-binary	Men
Corequisite	12	0	12
Lecture A1	20	1	21
Lecture A2	20	1	28
Lecture B	20	0	13
Lecture C	16	1	30

The gender makeup of the observed courses is displayed in Table 5.7. When looking at the dataset in the aggregate, there was inequitable coded verbal classroom participation. The College Algebra women verbally participated (vocally or in the Zoom chat) less than what would be expected in a setting with proportional representation – the equity ratio for the College Algebra women was 0.847. An equity ratio is defined as the quotient of the share of actual participation to the share of classroom demographic representation. A value of one demonstrates that students participated proportional to their demographic representation in the course. For marginalized and/or minoritized groups, like women in STEM, an equity ratio less than one can be interpreted as evidence of an inequity.

Table 5.8 displays the contingency table of gendered participation trends across all five observed classes, where the expected distribution was hypothesized to be proportional to demographic representation in each class. A chi-square analysis showed a statistically significant difference (Holm-Bonferroni corrected) between the expected student participation and the observed participation in each class, regarding the level of participation of women and their peers within the observed courses $X^2(5, N = 1100) = 25.422$, $p = 1.155 \times 10^{-4}$).

Table 5.8. Contingency table for participation patterns of College Algebra women.

	Corequisite	Lecture A1	Lecture A2	Lecture B	Lecture C
Women	O: 131 E: 148	O: 67 E: 64.5	O: 125 E: 110.29	O: 115 E: 145.76	O: 59 E: 71.49
Other	O: 165 E: 148	O: 62 E: 64.5	O: 68 E: 82.71	O: 255 E: 224.24	O: 53 E: 40.51

Note. "O" represents the observed values, while "E" represents the expected values.

As highlighted in Table 5.9, women participated less than expected in many of the observed courses given the demographic make-up of their classroom. For instance, in the corequisite course the equity ratio for overall participation by women was 0.885, in Lecture B it was 0.789, and in Lecture C it was 0.825. However, in Lecture A1 and A2 course sections, women participated more than proportional with overall equity ratios of 1.039 and 1.133.

Table 5.9. Gender equity ratios by venue.

Course	Venue of Substantial Student Engagement	Man	Nonbinary	Woman
Corequisite	Overall (296)	1.115	-	0.885
	Chat (161)	1.193	-	0.807
	Breakout Room (123)	1.041	-	0.959
Lecture A1	Overall (129)	0.960	0.977	1.039
	Chat (111)	0.908	1.135	1.081
Lecture A2	Overall (193)	0.863	0	1.133
	Chat (127)	0.791	0	1.185
	Breakout Room (61)	1.04	0	1.004
Lecture B	Overall (370)	1.137	-	0.789
	Chat (267)	1.187	-	0.713
	Whole Class (82)	0.966	-	1.053
Lecture C	Overall (112)	0.944	7.133	0.825
	Whole Class (106)	0.998	7.538	0.783

Note. The venues of substantial student engagement refer to the venues where more than 15% of the participation sequences occurred.

Lecture C was the course with substantially less student engagement than the other observed courses. There was only one main venue for student engagement in this course; all but six of the student contributions in the Lecture C course section came from whole class discussions in the main Zoom room. Given that there were 47 students enrolled in the Lecture C course, each student would have been expected to participate about two times to ensure equal representation. This was not the case – recall, only 18 students participated throughout the observation period. Of the 18 students, the one student who identified as nonbinary contributed 17 times and thus was greatly overrepresented in the classroom discourse (equity ratio 7.133). On the opposite end, the one nonbinary student in the Lecture A2 course section did not show up at all in the data. This finding was also true even when including the participation sequences that were mandated and/or incentivized by the instructor (chat solicitations). The only other student in this study who self-identified as Nonbinary was enrolled in the Lecture A1 section and participated slightly less than proportional overall but slightly more in the Zoom chat.

When considering the venues in which students participated, some venues led to more unbalanced participation than others. Also included in Table 5.9 is a breakdown of participation within the venues of substantial student participation for each class. If there was minimal (less than 15% of the coded sequences) participation in the Breakout Rooms, then that venue was not included in the table. For example, the venues that yielded a substantial amount of student contributions in the corequisite course were the Zoom Chat and the Breakout Rooms, whereas the main Zoom room (Whole Class) was the venue of substantial student participation in the Lecture C course section. The venues with the greatest amount of participation for each class tended to foster unbalanced student participation. The Zoom chat was the source of unbalanced student participation for all observed courses except for Lecture C, which only had a single venue of substantial student participation. The Whole Class venue for Lecture C fostered unbalanced student engagement.

Student participation in the chat may have led to less than proportional student participation for certain groups of students. In the corequisite and Lecture B courses, women were underrepresented in the chat. For the Lecture A1 and A2 courses, men were underrepresented in the chat. The secondary venue for each of these courses provided an opportunity to shift the balance of student participation.

The chat provided a low stakes environment to participate without disturbing the flow of the lesson nor other students' learning. One would think that this venue would be an equalizer since there was a lower bar to entry and was accessible for any student logged into the classroom using a device with a keyboard (e.g., laptops, tablets, and phones). One hypothesis for the gender imbalance in the chat is related to confidence. Certain groups of students may have been more confident in their answers and thus were more likely to contribute freely to the chat. According to past studies, undergraduate men tend to be more willing to participate regardless of the veracity of their solutions (Lundeberg et al., 1994). This would certainly explain the imbalance in the corequisite course and the Lecture B course, but not necessarily the imbalance in the Lectures A1 and A2 courses where men were underrepresented.

Differences between STEM and. Non-STEM Majors

Participation imbalances also played out across majors. Though the College Algebra course is the first course in the STEM sequence at GSU for STEM-intending students who do not place directly into the Calculus sequence, there are still some Non-STEM students and students with undeclared majors enrolled in the course (see Table 5.10).

Table 5.10. Major distribution across courses

Course	Non-STEM	STEM	Undeclared
Corequisite	3	19	2
Lecture A1	10	24	8
Lecture A2	13	27	9
Lecture B	6	23	4
Lecture C	9	33	5

Table 5.11 displays the contingency table of participation trends between declared STEM majors and their peers across all classes, where the expected distribution was hypothesized to be proportional to demographic representation in each class. There was a statistically significant difference (Holm-Bonferroni corrected) between the observed and expected participation of STEM majors across classes, $X^2(5, N = 1100) = 63.862$, $p = 1.93 \times 10^{-12}$).

Table 5.11. Contingency table of participation trends across classes between majors.

	Corequisite	Lecture A1	Lecture A2	Lecture B	Lecture C
STEM	O: 214	O: 90	O: 121	O: 306	O: 96
	E: 234.33	E: 73.71	E: 106.35	E: 257.88	E: 78.64
Other	O: 82	O: 39	O: 72	O: 64	O: 16
	E: 61.67	E: 55.29	E: 86.65	E: 112.12	E: 33.36

Note. “O” represents the observed values, while “E” represents the expected values.

In the lecture course sections, the declared STEM majors participated at higher rates than their classmates. The opposite was true in the corequisite course, where students with undeclared and non-STEM majors participated more than expected (see Table 5.12). As shown earlier, the venue with the largest amount of student engagement tended to be the location of greater imbalance in student participation. This was not true for the corequisite course, where student participation by both groups of students were close to proportional in the venue with the most student engagement (Zoom chat). For Lecture sections A1, A2, and B, the Zoom Chat was the venue of unbalanced participation, and for the Lecture C course section the Whole Class venue continued to be the primary source of student engagement, which was also unbalanced.

Table 5.12. Participation patterns by major.

Course	Venue of Substantial Student Engagement	STEM	Non-STEM/Undeclared
Corequisite	Overall (296)	0.913	1.330
	Chat (161)	1.004	0.984
	Breakout Room (123)	0.822	1.678
Lecture A1	Overall (129)	1.221	0.705
	Chat (111)	1.198	0.736
Lecture A2	Overall (193)	1.138	0.831
	Chat (127)	1.229	0.719
	Breakout Room (61)	0.952	1.059
Lecture B	Overall (370)	1.187	0.571
	Chat (267)	1.258	0.406
	Whole Class (82)	0.910	1.207
Lecture C	Overall (112)	1.221	0.480
	Whole Class (106)	1.236	0.443

This imbalance in participation between declared STEM majors and their classmates was unsurprising since this course is a STEM course, and it is the first course usually taken by STEM-intending students (if they do not place higher). As stated by Dr. Washington, the course coordinator for the College Algebra courses at GSU, “Non-STEM majors are not supposed to be in this class.” In particular, the GSU math department offered a handful of other mathematics courses geared towards Non-STEM students who needed to fulfill their general education requirement. Thus, many of the College Algebra instructors tended to assume that their students were all STEM majors. In Ms. Johnson’s class, 14 out of the 47 students were either Non-STEM majors or had not declared their majors. Hence, most students in her class were indeed STEM majors.

In the following excerpt from the fourth day of observing Ms. Johnson’s class, she continuously made connections between the material she was introducing (the complex number system) and the material to be covered in future STEM courses that she assumed her students would take. Ms. Johnson had an applied mathematics background and regularly tried to link the College Algebra material to content she expected her students to encounter along their STEM journey.

> Ms. Johnson: If you are a math major, you are going to take classes later on where we actually deal with other number systems. So, for the sake of the regular progression through Calculus we just deal with the complex number systems.

In this episode, Ms. Johnson connected the current material to material that math majors will see in the future. Though no students in her class were declared math majors, this information still applied to STEM-intending students since they will all need to take the Calculus sequence for their majors.

Ms. Johnson then continued to emphasize the relationship between the material she was covering and future engineering courses.

> Ms. Johnson: So just as a reminder, most of what we are going to do in this class and most of what you will do in your future classes are going to be in the real numbers. But we do step out. Those of you that will be going into Electrical Engineering and Signal Processing you will be dealing with imaginary numbers.

Here, Ms. Johnson specifies which engineering majors/courses will be working with the complex number system. Though there were 17 declared engineering majors in her class, only three of them declared an Electrical Engineering major.

Later in the observation Ms. Johnson continued to connect the material to STEM majors, but this time she singled out computer science majors – there were four declared computer science majors enrolled in her class.

> Ms. Johnson: Can somebody give a thumbs up in the chat or on your screen if you have done computer programming and you have heard of the operation called modulo?

One student gave a virtual thumbs up using the *Reactions* button on Zoom. Ms. Johnson then went on to connect how powers of *i* related to modular arithmetic and ideas used in computer science. These examples showcase the lengths taken by Ms. Johnson to make explicit the connections between the material she was covering and the future material that STEM students will learn. While these moves are great for getting student buy-in to the course content and to be more engaged with the lesson, it may have also excluded students from the conversation. Her examples directly applied to about seven students and were broadly relevant for about 21 of her 47 students. Thus, there was a potential for the remainder of the students, including the 14 Non-STEM/Undeclared students, to feel excluded from the conversation due to how fine-grained her examples may have been.

Lastly, the primary venue of participation was unbalanced in many of the courses – the STEM students were greatly overrepresented in the classroom discourse within these courses. The Lecture C and A1 courses primarily had participation in a single venue, thus there were no secondary venues to engage more students. Like with the gender analysis, the secondary venues in these courses (the breakout room for Lecture A2 and whole class for Lecture B) presented as opportunities to shift the balance of student participation. However, unlike the lecture course sections, the STEM and Non-STEM/Undeclared students in the corequisite course had nearly proportional representation in the primary venue of participation (Chat). It was in the secondary venue, the breakout rooms, where the Non-STEM/Undeclared students were overrepresented.

Shifting the Balance

There was more than one venue of substantial student engagement in the corequisite course and the Lecture A2 and B courses. The use of breakout rooms in the corequisite and the Lecture A2 courses, and the whole class discussions in the main Zoom room in the Lecture B course were opportunities to shift the balance of student participation, in terms of gendered participation and participation by declared major, towards proportional student engagement overall. In this final sub-section, I describe two ways instructors were able to shift the balance of student participation in the virtual classroom.

Engaging More Students in the Breakout Rooms. Ms. Addison regularly used breakout rooms in her corequisite course. Four out of the six observations contained segments of class-time spent in the breakout rooms. Typically, the breakout rooms consisted of three to four students working on a group activity related to content they learned or would learn in their lecture course. The group dynamics varied from group to group. Ms. Addison encouraged students to unmute themselves and to work together while one group member shared their screen with everyone else. Occasionally, Ms. Addison would hop into different groups to hear about the progress they had made in a class activity. In the following excerpt, Ms. Addison joined a breakout room where students were quiet, and their videos were off.

Ms. Addison:	Okay, which problem are you looking at?
Hassan:	Umm the second one
Ms. Addison:	The second one, okay.
Hassan:	So, I took out a 3 to get x^2-9b^2
Ms. Addison:	Great
Hassan:	But I am not sure what steps I should take after that.
Ms. Addison:	Okay, what about the rest of your group. What do you think after that? What's a good next step?
Hassan:	I don't know. I'm just I think I'm lost.
Ms. Addison:	Okay, how about Liliana, Ahmed?
Liliana:	I already solved the problem.
Ms. Addison:	Okay what did you get?
Liliana:	I put it in the chat. Oh, I can't see it in the chat.
Ms. Addison:	I can't see because we just joined your group.
Liliana:	I will put it again.
Ms. Addison:	Ahh (gestures thumbs up)
Emmanuel:	That's what I thought was the answer but then I thought that was wrong. Oh, that's the right answer?
Ms. Addison:	Yeah.

Emmanuel:	Then I had the right... I thought that … I wrote that but then I thought we had to like when we foil it out it would be the answer before, but I wasn't sure if that was the answer.
Liliana:	It looks wrong, but I checked.
…	
Ms. Addison:	Ahmed did you have something to add?
Ahmed:	No, I have the same answer.
Ms. Addison:	Oh, very nice! So those are things we check for, the difference of perfect squares …

Prior to Ms. Addison's entry, the students in this group were working independently on the group activity. When Ms. Addison entered, Hassan pointed out that he was confused. Instead of answering Hassan's question, Ms. Addison asked his group members to respond. Liliana then shared her solution, which then led to Emmanuel sharing that he also had that solution but was also confused. Ms. Addison's push to get students to lead the conversation allowed for opportunities for learning from each other and receiving mutual validation. Hassan was not the only one who felt confused about the activity, and this was validated by Emmanuel's admission. Liliana validated Emmanuel's process of thinking after he explained his thought process for not initially accepting his final answer.

Even after Ms. Addison's initial push to get Ahmed involved in the conversation, he abstained. Later, she recognized that Ahmed still was not involved in the discussion, so she asked if he had anything to add. After he responded, she did not push further but complimented him for arriving at the same answer as his groupmates. Ms. Addison's pedagogical moves in the breakout room made way for greater student participation and greater student-student interaction. She used these opportunities to promote more student discourse and to elevate student ideas – this is a concrete step towards positioning students as knowledgeable members in the mathematics community and in creating equitable and inclusive learning environments.

Calling on Students to Participate in Whole Class Discussions. While Ms. Martinez (Lecture B instructor) engaged with students heavily in the chat, she also called on students during the whole class setting to ensure that they understood the material and were following along. Occasionally she would call on students to elaborate on ideas they may have stated in the chat. As counterintuitive as it may seem towards creating equitable learning experiences, there has been some research (e.g., Dallimore et.al, 2019) suggesting that such pedagogical moves (cold-calling) are beneficial for improving student engagement without making students overly uncomfortable. At the very least, this practice of cold-calling students helped establish the classroom norm of student engagement where students expected to participate during every class meeting.

In the following excerpt from the third day of observing the Lecture B course, Ms. Martinez presented a picture of a piecewise function and asked students to state the value of the function at a particular point.

Ms. Martinez:	What is f(6)? What solution would I have? Put it in the chat.
Tina (chat):	none
Ariana (chat):	nowhere
Frederico (chat):	d.n.e
Angelica (chat):	dne
Ariana (chat):	It doesn’t fit within the domain.
Ms. Martinez:	Angelica, could you explain. I totally agree with you, but can you just explain your answer?
Angelica:	Umm since the domain only goes up to 5, 6 wouldn't be on there
Ms. Martinez:	Exactly so 6, this particular function, this function does not exist at x = 6.

Recall, in Lecture B, women and Non-STEM/Undeclared majors were underrepresented in the classroom discourse within the chat venue. That finding is not evident within this snippet of the classroom discourse. However, Ms. Martinez routinely worked to shift the balance in student participation by explicitly calling on students to participate. In her initial prompt, she asked students to post solutions in the chat. After receiving five versions of the same answer, Ms. Martinez chose to call on Angelica, a woman with an undeclared major, to explain her reasoning for posting the answer that she did. After Angelica elaborated, Ms. Martinez evaluated and formalized Angelica's response.

These types of exchanges were very common in the Lecture B course, where the instructor routinely called on students to unmute and contribute to the whole class discussions. As described at the start of this chapter, Ms. Martinez also called on ULAs to contribute to the class discourse in this manner. Thus, unmuting and vocally participating became a classroom norm in Ms. Martinez's class. Students were always prepared to unmute and vocally participate just in case Ms. Martinez called on them to participate. This explains why over 92% of the students in Ms. Martinez's class vocally participated at some point during the observation period.

There were some instances where students were unable to participate in this manner, as in the following excerpt from the third day of observing Lecture B:

Ms. Martinez:	Alright so I am going to be taking some answers. So, Mario, are you here? Mario can you quickly unmute yourself and tell us what you got for f(-1) … Oh you have some background noise, let's see. Let me go ahead and call on Eliza. Are you here?
Eliza (in chat):	Yes
Ms. Martinez:	Can you go ahead and answer f(-1), how did you do that one? Can you unmute yourself really quick?
Eliza (vocally):	Yes, there is just construction in the back.
Ms. Martinez:	Okay that's fine just as long as you … if you feel more comfortable writing in the chat.

Ms. Martinez called on two students to participate, and in both instances the students stated that they had background noises (Mario stated in a private chat, and Eliza made a vocal statement). Instead of questioning the students, Ms. Martinez simply offered another venue for the students to respond to the initial prompt. This type of flexibility was essential, given the added sources of inequity experienced by students in the virtual environment, such as internet insecurity and the lack of personal space to engage in coursework without external distractions. Ms. Martinez was able to shift the balance of student participation by creating norms in her class for student engagement where all students were prepared to participate during the lesson. In addition, she provided flexible options for student engagement for times when vocal engagement was not possible.

Corequisite Students in their Lecture Courses

Out of the 24 students enrolled in the corequisite course, 13 were observed in their lecture courses. As discussed earlier, the nature of student participation (solicitation methods, and the quality of student talk and teacher questions) in the lecture courses and the corequisite course was very similar. One main difference between the two types of courses was that the corequisite course used breakout rooms more frequently than the lecture sections. Thus, students had more class time to work with their peers, where they engaged in group activities.

Table 5.13. Contingency table of corequisite student participation in lecture sections.

	Lecture A1	Lecture A2	Lecture B	Lecture C
Corequisite	O: 16 E: 12.29	O: 11 E: 15.76	O: 42 E: 44.85	O: 3 E: 2.38
Other	O: 113 E: 116.71	O: 182 E: 177.24	O: 328 E: 325.15	O: 109 E: 109.62

Note. "O" represents the observed values, while "E" represents the expected values.

Displayed in Table 5.13 is the contingency table of observed and expected participation between corequisite students and non-corequisite (lecture-only) students. There was not a statistically significant difference in the observed and expected student contributions of the corequisite students in the lecture courses compared to their non-corequisite peers, $X^2(4, N = 804) = 3.173$, $p = 0.529$). Consistent with the previous findings, the 13 corequisite students mostly contributed to the classroom discourse unsolicited in both their courses; 95% of their contributions in the corequisite course was unsolicited compared to 83% in their lecture courses.

They contributed mostly shorter responses in both courses with only 7% of responses coded as "Long Response" in their corequisite course and 6% in their lecture courses. Most of the students' contributions were low-level with 95% of their contributions in the corequisite coded as low-level (Other and What) and 92% in their lecture courses.

One notable difference between the participation in the corequisite course and the lecture course was the proportion of contributions coded as "N/A" for Teacher Solicitation. In the corequisite course, 22% of the contributions were coded as "N/A" whereas only 10% of the lecture contributions were coded this way. An N/A teacher solicitation occurred when a student contributed to the class discussion without the instructor posing a question. In the corequisite course, 22 out of the 45 occurrences of the N/A teacher solicitation were instances where this group of students were responding to their peers' ideas – this occurred both in the whole class setting and in breakout rooms. In the lecture course the corequisite students responded to their peers only three times. Another difference between the corequisite students' experience in their corequisite course and their lecture was that their corequisite instructor responded to a greater proportion of their contributions (35%) whereas their lecture instructor responded to 29% of their contributions. A final difference between the 13 corequisite students' participation in their courses was the venue from which their contributions came. In the corequisite course, 42% of their contributions occurred in the breakout rooms whereas only 13% of their contributions in the lecture course came from the breakout rooms. Again, this is unsurprising given the amount of time students spent working collaboratively in breakout rooms in the corequisite course.

In total, the 13 corequisite students participated in their lecture courses more than expected given their representation (equity ratio 1.18). In considering the lecture course sections individually, the corequisite students had slightly less than proportional participation only in Ms.

Martinez's Lecture B course. While they were underrepresented in the chat venue, they participated more than expected in the Whole Class setting in Lecture B (see Table 5.14). The corequisite students' activity in the other lectures were either more than expected (Lectures A1 and C) or less than expected (Lecture A2). As explained earlier in the chapter, the use of a secondary venue for student engagement helped shift the balance of participation towards elevating other voices; this is certainly the case for the Lecture A2 and B courses. Again, Lectures A1 and C only had one venue where students participated consistently, thus participation imbalances in those courses were sustained throughout the observation period.

Table 5.14. Equity ratios for corequisite students in lecture courses compared to their peers.

Course	Venue of Large Portion of Student Engagement	Corequisite Students	Lecture Students
Lecture A1	Overall (129)	1.302	0.968
	Chat (111)	1.419	0.956
Lecture A2	Overall (193)	0.698	1.027
	Chat (127)	0.482	1.046
	Breakout Room (61)	1.205	0.982
Lecture B	Overall (370)	0.936	1.009
	Chat (267)	0.73	1.04
	Whole Class (82)	1.31	0.96
Lecture C	Overall (112)	1.259	0.994
	Whole Class (106)	1.330	0.993

Discussion

In this chapter I presented quantitative and qualitative findings from classroom observations that described the nature of student participation in the corequisite course and lecture courses. In this section I answer the two research questions by reviewing these findings.

RQ 2.1 – How are opportunities to engage in course content distributed in corequisite courses vs. lecture courses?

The virtual classroom allowed instructors to engage students in multiple venues including the Whole Class (main Zoom room) where students openly shared in front of their peers and instructor, the Breakout Rooms where students collaborated in intimate groups, and the Zoom chat where students contributed to the whole class discussion publicly and non-vocally. All courses used at least two of these venues to involve students in course content during the observation period. The chat was a popular venue for student contributions across most observed classes. The students in the corequisite course spent a greater share of their meeting time working in breakout rooms than the students in the lecture course sections. This is not surprising for two reasons. First, and as described in Chapter 4, Ms. Addison (the corequisite instructor) stated a preference for more student engagement, therefore these findings align with her declared instructional practices. This is also not surprising given the purpose and structure of the corequisite course at GSU. As described by various institutional stakeholders in Chapter 4, the goal of the corequisite course is to provide students with just-in-time remediation and additional practice on course content. Thus, by design, the corequisite course allowed for more student engagement in course content and greater student interaction between each other and the instructor. In fact, the share of student voices heard in the corequisite course is a testament to how much more students vocally interacted in that course.

There were some similarities between the lecture course sections and the corequisite course. Like in the lectures, students in the corequisite course participated predominantly without being personally solicited. Secondly, most of the student talk and teacher solicitations were at a cognitively low level. There were also many notable differences between the lectures and the corequisite course. Almost all the students in the corequisite course participated at some point during the observation period – this is not true for the lecture course sections. Thus, the corequisite course was more successful at getting students to contribute to the virtual discourse than the lecture course. Another difference was that a greater share of the student contributions in the corequisite course were long responses when compared to the lectures. This may have been in part due to the venue of student participation. As previously noted, the corequisite course utilized the breakout rooms much more than the lecture course sections, therefore students were more likely to provide longer utterances than the short utterances typically seen in the public chat. Lastly, Ms. Addison (the corequisite course instructor) responded to a larger share of student contributions than the lecture instructors. This practice aligned with the goals of the corequisite course of supporting students in learning lecture course content. Students in corequisite courses tend to need additional academic support, thus it is imperative that the instructor provide consistent and immediate feedback to the students by responding to their ideas.

Proportional participation, where students participate at levels equivalent to their demographic representation in the class, was an issue in all observed classes. In the corequisite course, women were underrepresented in the classroom discourse. This was also the case for many of the lectures. This imbalance was prominent in the primary venue (chat) of student engagement. The breakout rooms, which served as a secondary venue for student contributions in the corequisite course, proved to offer greater gender balance in student participation. In this venue the instructor engaged smaller groups of students where students participated more freely. Ms. Addison encouraged all students to actively participate, and by the end of the observation period she was able to get 23 out of the 24 students to participate at least once during the observation period.

Participatory equity was also a problem between declared STEM majors and their classmates. Non-STEM and students with undeclared majors made up a smaller share of the corequisite and lecture courses, and more often these students participated at rates less than proportional to their representation. There were instances where these students may have been excluded from the classroom dialogue due to the assumption that only STEM-intending students would take College Algebra. In the corequisite course, however, Ms. Addison was able to get these students more involved in the classroom discourse. Once again, the secondary venue (which was the breakout room for the corequisite course) allowed for students to engage more openly with Ms. Addison and their peers, and by the end of the observation period Non-STEM students and students with undeclared majors became overrepresented in the classroom discourse when compared against their STEM counterparts.

RQ 2.2 – How do students in corequisite courses engage in their lecture courses?

The data suggest that student participation in the corequisite course was important for positive course outcomes in their lecture course. This relationship did not apply to student participation in the lecture course sections. In addition, there was no significant difference in the number of contributions in the lecture courses between the corequisite students and their classmates. The participation patterns of the 13 corequisite students observed in both their corequisite course and lecture courses were similar across virtual classrooms. Consistent with previous findings, an observed difference was that the corequisite students participated more often in breakout rooms in their corequisite course than in their main course. Another difference was that more of their contributions were acknowledged in their corequisite course than in their lecture course. Finally, more of the student contributions in the corequisite course were initiated without being personally solicited by their instructor. Of these contributions, about half (22 out of 45) were direct responses to the ideas of their peers. These findings suggest that the corequisite course fostered an environment for more open and active dialogue between students. In this course, students had more opportunities to work collaboratively on course content from their lecture course and to review problems from their homework and quizzes. In the next chapter, I discuss more intently students' experiences in their corequisite courses, and the impact the corequisite had on student affect (e.g., attitudes towards mathematics, and confidence in doing mathematics) and their overall experience in their lecture course.

Chapter 6: Student Experience

In Chapter 4, I provided institutional context for corequisites at Grizzly State University (GSU), by elaborating on the perspectives of instructors and institutional stakeholders. In Chapter 5, I highlighted how students participated in the corequisite and lecture courses, and how instructional moves helped facilitate greater student engagement. The focus of this chapter is the student experience communicated through the voices of the student participants. The results from this chapter will address the third research goal of understanding the impact of corequisites on the student. The focusing research question is, *how are students' interests, beliefs, and attitudes around mathematics and mathematics learning affected through enrollment in the corequisite course?*

GSU took a comingled approach to implementing their corequisites. This means that all College Algebra students were enrolled in a section of a College Algebra lecture course that met three days a week (Monday-Wednesday-Friday) each for 50 minutes. Those students identified as needing additional academic support were enrolled in an additional one-unit support course that also met three days a week (Monday-Wednesday-Friday) for 50 minutes each. Friday lecture classes were either reserved for synchronous group quizzes, asynchronous individual quizzes, and/or an asynchronous lecture video. Friday support classes were open hours for students to continue working on homework or to get support on course material. The experience learning College Algebra, for the corequisite students, was thus shaped by both the lecture and support courses.

This chapter brings students' experiences in both the lecture and corequisite course to the forefront. It begins with a review of the methods, followed by a discussion around placement and a characterization of the students that were placed in the corequisite course. Student engagement in the lecture and corequisite courses is documented in the following two sections. Afterwards, *student affect* regarding classroom structures is discussed. Student affect in this context refers to the expressed interest, values, beliefs, and attitudes towards mathematics (Nieswandt, 2007; Popham, 2009). The chapter concludes with a discussion of the presented findings and how it answers the research question.

Methodological Approach and Data Sources

Three data sources were used to triangulate the experiences in each class. The first data source was coded transcripts from corequisite student interviews and focus groups of (non-corequisite) lecture students. The demographic breakdown of the interview participants is displayed in Table 6.1.

Table 6.1. Demographics of interviewed corequisite and lecture students.

Student	Lecture Instructor	Enrolled in the Corequisite?	Gender	Race/Ethnicity	Declared a STEM major?
Adriana	Ms. Johnson	Yes	Woman	Hispanic/Latinx	Yes
Amanda	Ms. Johnson	Yes	Woman	Hispanic/Latinx	Yes
Chih-Wei	Ms. Martinez	Yes	Man	Asian	Yes
Gloria	Ms. Rose	Yes	Woman	Hispanic/Latinx	Yes
Isbelia	Ms. Addison	Yes	Woman	Hispanic/Latinx	Yes
Jeffrey	Ms. Addison	Yes	Man	White	Yes
Rachel	Ms. Addison	Yes	Woman	Asian	Yes
Caleb	Ms. Johnson	No	Man	White	Yes
Vanya	Ms. Johnson	No	Woman	Hispanic/Latinx	Yes
Angelica	Ms. Martinez	No	Woman	Hispanic/Latinx	No
Kim	Ms. Johnson	No	Woman	White	Yes
Carlos	Ms. Johnson	No	Man	Hispanic/Latinx	Yes
Miguel	Ms. Martinez	No	Man	Hispanic/Latinx	Yes
Tina	Ms. Martinez	No	Woman	Hispanic/Latinx	Yes

The second data source was the Student Postsecondary Instructional Practices Survey – Mathematics (SPIPS), where students reflected on their classroom experiences, their perceptions of the classroom activity, and their perceptions of learning and doing mathematics (Apkarian et al., 2019). This survey included both Likert scale items and open response questions. Students completed the SPIPS during the last two weeks of the Fall 2020 semester. 132 students responded, of them 117 fully completed the survey – only seven of the 24 registered corequisite students completed the survey. The response rate of the survey was about 39%. Given that 99% of the survey respondents reported expecting a final grade of C or better compared to the 82% of all College Algebra students that did receive a final grade of C or better, there was a potential response bias. Similarly, all seven corequisite respondents reported expecting a grade of B or higher whereas 71% of all the corequisite students received a final grade of B or higher. Thus, the survey responses may have been biased towards students who were passing or expected to pass the course.

The final data source was corequisite student reflections from the ninth and 16th week of the semester. Students were asked to reflect on their most recent quiz, where they identified main reasons for missing points on the quiz and stated explicit goals for avoiding the same mistakes in the future. In addition to this metacognitive activity, students were asked to predict their course grade at the time of the survey, state the lowest grade they would be happy with, and to identify what has and has not been effective for them in the corequisite course.

Data Analysis

Descriptive and statistical analyses (e.g., paired, and independent samples t-tests) of the survey data were used to contextualize the data and to measure whether perceived differences were beyond what is reasonable due to chance. In addition, a qualitative analysis was conducted on transcripts from student interviews, open responses in the SPIPS, and student reflections from the ninth and 16th weeks of the semester. These data were cleaned and coded using a thematic analysis approach (Braun & Clarke, 2006).

The qualitative analysis occurred in six phases, where the first phase included data cleaning and annotation for interesting features. In the second phase, initial codes were generated based on salient features throughout the dataset. In the third phase, codes were grouped according to themes with supporting evidence. Three recurring themes arose throughout the various data sources: *placement*, *virtual engagement*, and *student affect*. The identified themes were then refined by investigating whether the meanings were valid in relation to the context and the data. Finally, each theme was explicitly named and defined in accordance with what it described and the details from the data that was captured by the theme. Afterwards, I consulted with a second coder to double code a subset of the student interviews. Through conversations about the subcodes, the themes, and the data itself, we developed clearer and stronger definitions for each of the themes (see Table 6.2).

Table 6.2. Definition of themes from student interviews.

Theme	Description of the Theme
Placement	Discussion about placement procedures and/or how students were recommended to the course that they are enrolled in.
Virtual Engagement	Discussion about classroom structures that contributed to their engagement. This includes working in groups, nature of their classroom participation, and sentiments around the class climate that would have affected the way they engaged in the classroom.
Student Affect	Discussion about the corequisite experience (course and/or instructor) and its influence on student interest, values, confidence, enjoyment, and understanding of course material.

It is worth noting that these themes are not mutually exclusive. For instance, in terms of placement, a student may have negative thoughts about placement which in turn influence how they engage in their course, and vice versa. How students engage in their course can influence their perceptions about their placement in the class. Similarly, the types of opportunities provided for student engagement can influence a student's attitudes and beliefs about mathematics. And vice versa, a student's attitudes and beliefs can shape how they engage in mathematical activities. Finally, if a student has strong beliefs about their placement (whether misplaced or appropriately placed), these feelings can color their perceptions of the effect of the course on their affective states; the opposite is true as well.

The first theme, around placement, emerged in Chapter 4 when discussing the institutional context from the lens of the various institutional stakeholders. Placement, specifically placement within the corequisite course, will be presented in this chapter through the lens of the student. Student engagement in the virtual environment was described in Chapter 5, where student participation in their courses were documented and analyzed. This current chapter adds another layer to this conversation by highlighting student perceptions on engagement in their virtual classes. Finally, the third theme around student affect is discussed in the penultimate section of this chapter.

Placement in the Corequisite

In Chapter 4, I discussed how students were placed in the corequisite course. In accordance with the executive order that brought about GSU's cultural change towards offering corequisite courses, the Chancellor's office developed a mechanism for student placement based on multiple measures (e.g., high school grade point average, scores on standardized exams, previous courses taken). This placement system categorized students into four groups where students in the third and fourth group were required to take the College Algebra course with a corequisite support. As of the time of data collection for this study, there was no way for students to self-place into the corequisite course. However, students could place out by taking a skills assessment exam to demonstrate that they already developed the mathematical skills needed for a higher-level course.

As some of the instructional leaders indicated, there were people in the corequisite that did not need to be there and other students who needed the corequisite support but were not placed in the class. This sentiment was echoed in the student interviews and reflections – five of the corequisite students (Adriana, Chih-Wei, Rachel, Jeffrey, and Emmanuel) expressed confusion about their placement in the course. Rachel shared,

> So, for my degree evaluation it says that I need to take this class, but when I took the placement test, I actually scored to be in [Pre-Calculus] … I think, I can't exactly remember but I would still have to take the [corequisite] class. Like no one told me. It was just on my degree evaluation, that in my first year at [GSU] I have to take this class to complete the requirement.

Rachel expressed confusion about her placement because though she was placed into a higher math class after taking GSU's skills assessment exam, an administrative form based on the Chancellor's category system recommended she take the corequisite course for the College Algebra course. In other words, Rachel was categorized in the third or fourth group indicating that she needed to begin her mathematical journey in the College Algebra course with a corequisite support. Rachel's results on GSU's skills assessment exam demonstrated that she had the prerequisite skills to begin her journey in Pre-Calculus instead. Unfortunately, this new Pre-Calculus placement was not reflected in Rachel's degree evaluation form, which is a form used to guide students' course selections. Without seeking further clarification, Rachel ended up just registering for the College Algebra course with the corequisite support.

In his reflection during the ninth week of the semester, Emmanuel (a corequisite student in Ms. Martinez's lecture class) highlighted his confusion in response to the prompt *What has not been effective so far in our course?* by stating, "for me would be being in the [corequisite] class."

He did not feel that he needed the additional support, and unfortunately as of the time of this study, there were no straightforward institutional remedies to ameliorate this problem. In other words, there was no way to place students into the corequisite that needed it (outside of the Chancellor's initial placement), and place other students out of the course that did not. Thus, understanding students' experiences in both the corequisite and lecture courses was important for two reasons. First, the corequisite student experience in College Algebra at GSU was shaped by both the lecture and corequisite courses. Second, due to GSU's placement procedures (as dictated from the Chancellor's office) there may have been students in the lecture course that needed additional support but were not offered a corequisite placement. Understanding the overall student experience in both courses can help inform future course development initiatives to support all learners while GSU makes changes to their placement procedures.

Who were the Corequisite Students?

The corequisite class was made up of 24 students who were diverse in many ways, including age, race/ethnicity, national origin, and intended major. Students self-identified as Asian (five students), Black (one student), Hispanic/Latinx (11 students), and white (seven students). Twelve of the students self-identified as women, and the other twelve self-identified as men. 19 of the corequisite students were STEM-intending, three were Non-STEM-intending, and the remaining two students were undecided. In addition, at least three of the corequisite students were International students and were attending the class synchronously between the hours of 11pm and 3am their local time.

The corequisite students brought with them a variety of life experiences, and as illustrated earlier, due to placement discrepancies corequisite students represented a range of mathematical ability. Five of the seven corequisite students interviewed (Isbelia, Amanda, Adriana, Chih-Wei, and Jeffrey), stated that they were not good at math. Six of them (all but Gloria) stated that they had negative experiences learning mathematics in the past. Four of the corequisite students (Jeffrey, Rachel, Chih-Wei, and Adriana) interviewed shared that their personal identity had impacted their learning throughout their math career.

Jeffrey was a returning student, after ten years of being out of school. He described that as a former high school student athlete, he was more focused on sports than schoolwork, thus he did not have a good relationship with mathematics. Now, with some years of maturity and experience as an active-duty soldier, he is more serious about his learning, and he approaches every class as an opportunity to learn something new.

For Adriana, her identity as a Latina from a low-income community affected her experience learning during the semester. She shared,

> I think I noticed mostly when it impacted me like last semester in my [College Algebra lecture] and [corequisite class], just because I saw a lot of like white students … and like they knew like a lot more than I feel like I ever knew like with math at all. Just because I feel like they probably had those extra resources and like actual private tutors and stuff like that, and like with me, being a low-income student, like I wasn't really accessible to like those sorts of things. So yeah, that's like the only way I really felt like [my identity] affected me because, like I kind of felt like I was behind.

Adriana felt marginalized in her classes due to the perceived difference in academic ability between her and her white classmates. Whether these students did know more than her, Adriana’s perceptions about their superiority were based in her perceptions about her own academic preparation. This sentiment caused her to feel like she was falling behind in the class. Adriana was a student in Ms. Johnson’s lecture class. In Chapter 5, it was discussed that Ms. Johnson’s class did not have a lot of student engagement, and that only 16 out of the 47 students (about 34%) vocally participated during the observation period. Adriana was one of the 16 students that did participate in Ms. Johnson’s class. However, Adriana’s comment about white students brings into question, *who* were the other 15 students that participated in Ms. Johnson's class and whether those voices caused a similar reaction in other students as it did with Adriana. In contrast to Ms. Johnson's class, 19 of the 24 corequisite students (about 79%) vocally participated during the observation period – Adriana was one of these students.

Rachel and Chih-Wei reported on how their Asian identities affected their experience learning mathematics throughout the years. Rachel shared,

> Because being Asian, there's this model minority that we're good at school, and especially good at math, which puts a lot of pressure on like me because it makes me think, oh, I have to be great at math, or I'm going to be a failure. So, it makes me want to try harder. But also, like I said, it puts all this pressure on me.

The model-minority trope, though a positive stereotype, caused Rachel to feel added pressure to succeed and anxiety about not meeting those standards. Chih-Wei echoed this sentiment,

> Well, I'll say … it's like one of those stereotypes of like Asians they're good at math. I just feel like I don't live up to that. In like, in local school they like, they ... I'm pretty sure they teach Algebra 2 or something like that when you're in middle school. So, it's like, I feel like if someone that's like ninth grade can do what I'm doing right now, just kind of feels bad.

Due to COVID-19, Chih-Wei was logging into his classes in his home country of Taiwan, which was about a 15-hour time difference. While home, various family members would comment on how "easy" the content was that he was learning. The *Asians are good at math* stereotype affected him directly when constantly reminded that he was placed in a lower math class than some of his younger relatives who were attending the local school. Chih-Wei was coping with such micro-aggressions while also navigating a full academic schedule during odd hours of his day due to the 15-hour time difference.

Virtual Engagement – Inside the Lecture Classroom

To fully understand the corequisite student experience, it is important to learn about the classroom environment in both the lecture courses and the corequisite support course. In this section I examine the second theme around virtual engagement, specifically in the lecture course. There were four instructors of the eight sections of the College Algebra lecture course at GSU: Ms. Addison (who was also the instructor for the corequisite course), Ms. Martinez, Ms. Johnson, and Ms. Rose. Sections of the first three mentioned instructors were observed and described in Chapter 5. Ms. Rose's class was not observed primarily due to scheduling conflicts.

In Chapter 5, I illustrated how different the lecture and corequisite courses were in terms of student participation. For one, students in the corequisite course spent more time working in groups within Zoom breakout rooms than any of the students in the lecture courses. These findings were somewhat echoed in student responses in the SPIPS (see Figure 6.1).

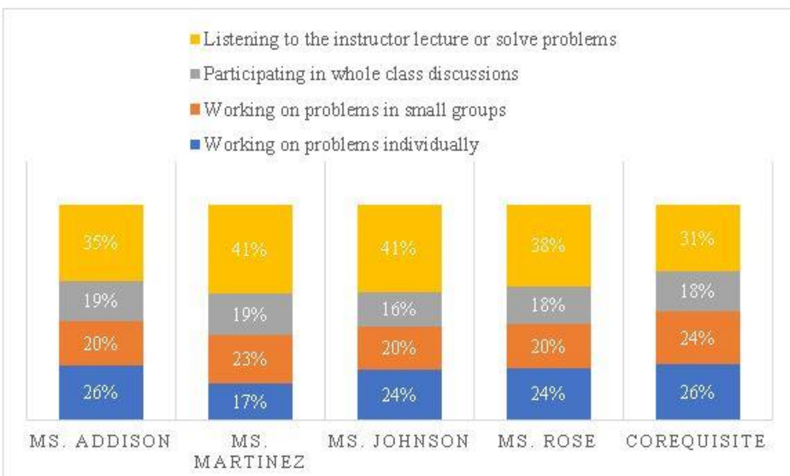

Figure 6.1. Student perceptions of the distribution of class time.

In the lecture course sections, students reported that a great amount of class time (between 35-41%) was devoted to the instructor lecturing and working through problems. In comparison, students in the corequisite reported spending about 31% of class time listening to the instructor lecture or solve problems. For most lecture sections (except Ms. Martinez's class), students working on problems individually consumed the next largest share of lecture time (between 24-26%). This was the same for the corequisite course where students reported working independently about 26% of the time. For Ms. Martinez, small groupwork made up the second largest share of class time (around 23%); for every other lecture section, small group activity consisted of about 20% of class time. The corequisite students reported spending about 24% of their class time working in small groups. This, however, was not consistent with what occurred during the observation period. Out of the six observations of the corequisite course, students worked in small groups in the breakout room in four of them; this amounted to 111 out of 300 class minutes (37% of class time) working in small groups. Lastly, whole class discussions made up the smallest share of class time across all classes (between 16-19%), including in the corequisite (18%).

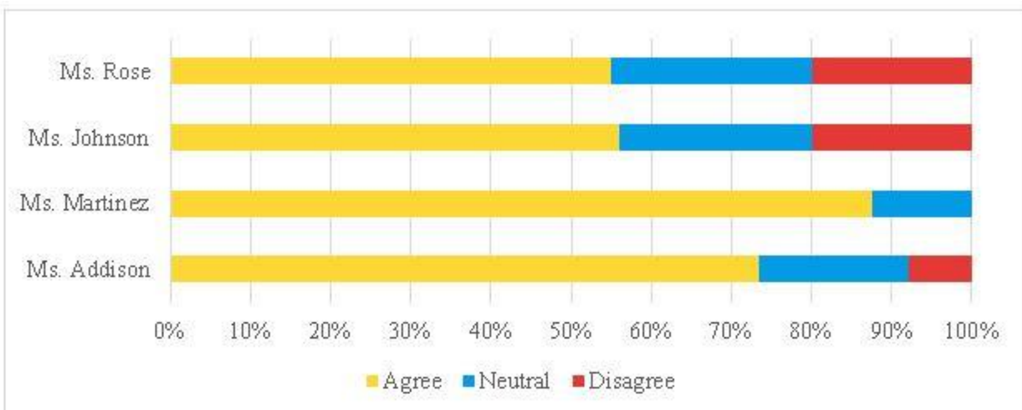

Figure 6.2. Responses to "I am asked to respond to questions during class time."

There were also differences in students' reports about being asked to respond to questions during the class lecture. As seen in Figure 6.2, a greater share of Ms. Addison and Ms. Martinez's students shared that their instructor asked them questions during class time. This finding was consistent with what I witnessed during the classroom observation period, where Ms. Addison and Ms. Martinez regularly engaged students by asking them to unmute and contribute to the class discussion or to respond to questions in the chat. Ms. Johnson did solicit participation by posing questions throughout her lecture, but unlike Ms. Addison and Ms.

Martinez, she did not call on particular students to participate nor did she solicit the whole class to participate in chat (e.g., uttering "please type your answer in the chat"). Instead, Ms. Johnson would pose a question and whoever felt comfortable responding publicly would unmute and respond to the prompt. For instance, Caleb, a student in Ms. Johnson's class, shared in a focus group interview, "I do comment when she asks questions because I feel like she won't move on to the next part without someone answering them, so I feel like we'll just be sitting there if no one says anything." In fact, Caleb was one of the students that dominated the discourse in Ms. Johnson's class. He was motivated to participate due to the absence of other students volunteering to participate. This may explain why only 16 of the 47 students in Ms. Johnson's class vocally participated during the observation period.

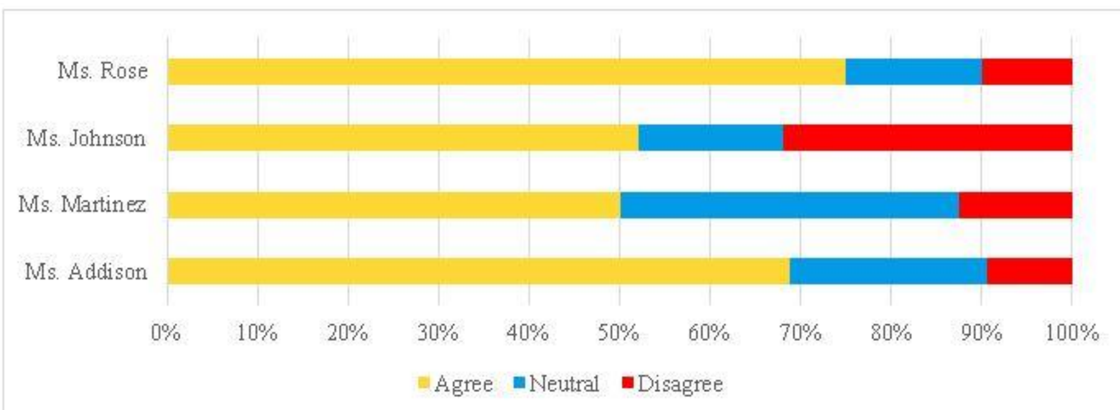

Figure 6.3. Survey item – Students have enough time to reflect on problem solving.

There were mixed reviews about the pace of the lecture course. More than 65% of the respondents enrolled in Ms. Addison and Ms. Rose's class reported having enough time to reflect about the processes used to solve problems. Students in Ms. Johnson and Ms. Martinez's classes did not report the same experience. As illustrated in Figure 6.3, more of their students either were neutral or disagreed. This is consistent with what students shared during interviews.

Adriana, a corequisite student enrolled in Ms. Johnson's lecture class characterized the class as "chaotic." She shared,

> Um honestly that was kind of chaotic just because it was such a big class and there was only one Professor. And, as she would be going all over the notes and all over the questions like she would go over really fast and like I don't know … because I know I'm really shy, so I tend to like say 'oh like I'll email her later, like I'll ask her later,' but I never really did. So, like I kind of like got lost a lot of the times. We usually in [the corequisite] … [Ms. Addison] would like go more in depth into what we were learning in [the lecture] so it did work out.

Adriana would get lost in her lecture course due to the fast pace, and she relied on the corequisite course to learn course content. Another interviewed corequisite student, Chih-Wei, who was enrolled in Ms. Martinez's class reported a similar experience in his lecture class.

> I'll say the lecture course is more intense. I feel like during the lecture course we had to like move faster, so we won't fall behind. But then for the [corequisite], like the professor would like stop and then answer our questions and then make sure that we understand what the math is.

Both students contrasted their experience in their corequisite with what they described as a "chaotic," "intense," or in other words fast-paced lecture class. The corequisite course was slower in pace and presented as an avenue to dig deeper into the lecture content.

Climate and Inclusion in the Lecture Course

There were mixed sentiments about whether there was a sense of community in the lecture course sections (see Figure 6.4). A greater share of survey respondents from Ms. Martinez's class felt that there was a sense of community in their lecture class compared to the respondents in other classes. Chih-Wei shared in his interview that students in Ms. Martinez's class created a class Discord page to communicate about things happening in their class. Discord is an online messaging platform organized via topic-based channels, where groups of people across the internet can collaborate and share files including video and voice messages. Similarly, students in Ms. Addison's class created a class GroupMe account to communicate with each other. Like Discord, GroupMe is a text-based phone application for groups of people to stay in contact.

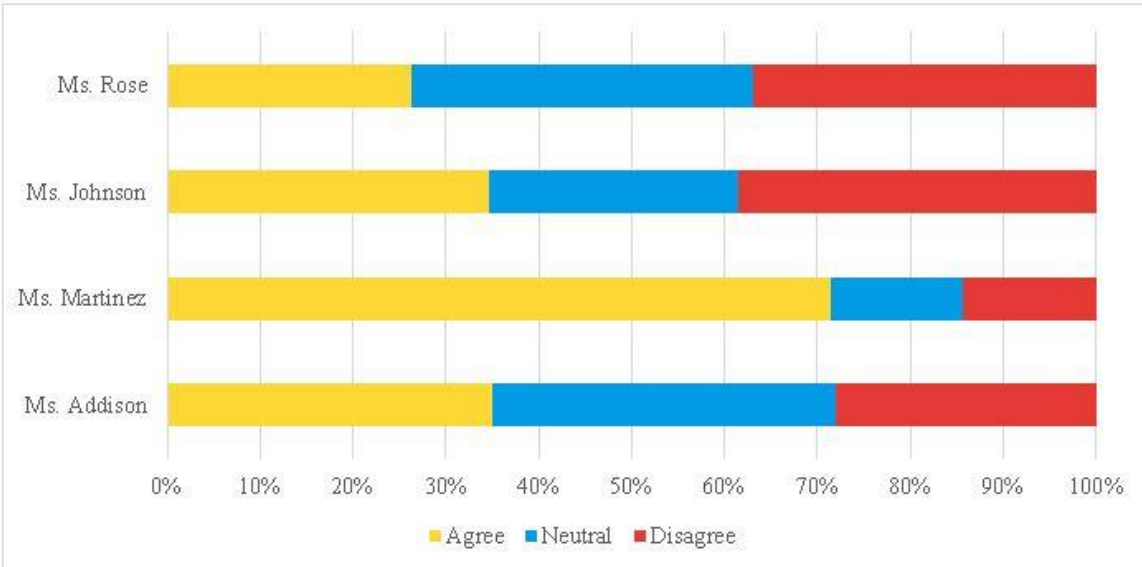

Figure 6.4. Responses to "There is a sense of community among students in my class."

Compared to the other instructors, a greater share of the respondents in Ms. Rose and Ms. Johnson's class disagreed about there being a sense of community in their lecture class. During an interview, Caleb (a non-corequisite student in Ms. Johnson's class) characterized the classroom climate as "anonymous." He continued, "so, I didn't know anyone in the class. I still don't know anyone in class. So, it's basically you're in there by yourself." Vanya, another interviewed non-corequisite student in Ms. Johnson's class added "I feel like we're all very respectful in the class, which I appreciate because compared to high school like sometimes someone would get the answer wrong and like another person would tease that person about it." So, while Caleb characterized the classroom climate as anonymous or cold, Vanya pointed out that at the very least everyone was respectful to each other.

Students were asked on the SPIPS to rate the overall climate in their College Algebra course on three five-point Likert scales. The first scale prompted them to rate the climate from

“Excluding and Hostile” (rating of one) to “Including and Friendly” (rating of five). The mean score along this measure was 4.37, which indicated that they perceived their lecture course as inclusive and friendly. On the second scale, they rated the climate from “Intellectually boring” (rating of one) to “Intellectually stimulating” (rating of five). The mean score for this measure was 3.61, which was in between the two poles, yet the score indicated that, on average, students found their lecture course more intellectually stimulating than boring. The final climate scale asked students to rate their course from “Academically easy” (rating of one) to “Academically rigorous” (rating of five). The mean score for this measure was 3.11, indicating that on average students perceived the course to be in-between easy and rigorous but more rigorous than easy.

Students were asked six questions on the SPIPS regarding feeling included in the classroom. These survey items were rated on a five-point Likert scale from “A lot less than other students” (rating of one) to “A lot more than others” (rating of five). Table 6.3 displays the differences in responses between corequisite students and their peers regarding feeling included in the lecture course. For most of these survey items, the non-corequisite students rated items on the inclusion scales slightly lower than the corequisite students. Corequisite students reported being helped from their lecture instructor more than their peers. Note, the mean score for the corequisite students for this item was three, indicating that they felt that they were helped just as much as any other student. In fact, most scores for both groups were close to three, indicating that students perceived they were included just as much as their peers.

Table 6.3. Perceptions of being included in the lecture class.

	Support	N	Mean	Std. Deviation
How much opportunity do you get to answer questions in class?	Non-corequisite	109	2.92	0.595
	Corequisite	7	2.71	0.756
How much attention does the instructor give to your questions?	Non-corequisite	109	2.92	0.454
	Corequisite	7	3.00	0.000
How much help do you get from the instructor?	Non-corequisite	109	2.89	0.515
	Corequisite	7	3.00	0.000
How much encouragement do you receive from the instructor?	Non-corequisite	109	2.94	0.436
	Corequisite	7	3.00	0.000
How much opportunity do you get to contribute to class discussions?	Non-corequisite	109	2.95	0.498
	Corequisite	7	3.14	0.378
How much praise does your work receive?	Non-corequisite	107	2.95	0.421
	Corequisite	7	3.00	0.000

Summary

Though all lecture course sections were coordinated, student experiences varied in the lecture course depending on the instructor they had. For instance, a greater share of Ms. Johnson's students reported not having enough time to reflect on the processes used to solve problems. Therefore, students in her class may have perceived her class as more fast-paced than students in other classes. A greater share of Ms. Martinez's students reported there being a sense of community among the students in the class, whereas students in other classes may not have had the same perception of the classroom environment.

Across all classrooms, including the corequisite, students reported spending a plurality of class time listening to the instructor lecture or solve problems. In addition, students across all classrooms reported spending at least 36% of class time interacting in the classroom, either through whole class discussion or through small group work. This percentage was higher for the corequisite class and Ms. Martinez's class (42% each). This finding was particularly interesting given the virtual nature of the course. Without in-person classes, it was hard for students to meet their peers and to form relationships. The virtual nature of these classrooms had the potential of fostering a sterile classroom environment where students do not participate and rely heavily on the instructor to drive the classroom discourse. In these environments, it also can be hard to encourage student engagement in the virtual space. But as documented in Chapter 5, the instructors (some more than others) provided opportunities for greater student engagement by posing questions, soliciting participation, and facilitating collaborative learning activities.

Virtual Engagement – Inside the Corequisite Classroom

In this section I continue elaborating on the second theme of virtual engagement by focusing on the student experience within the corequisite course. The term "corequisite" was not a terminology familiar to the students enrolled in the corequisite course. These students referred to their corequisite course as a "support course," "tutoring," a "lab," or simply by its listed name in GSU's course catalog. Students were asked to describe their corequisite course to an incoming student during the interviews and again on the SPIPS. Below are some of their characterizations:

> "[The corequisite] is additional help and further explains the subject." – Rosa (from the SPIPS)
>
> "I would describe it more like a tutoring class because it does help you learn, and then you go, and it makes you better for talking communication. I will probably offer it to my friends and say, if you need the help, here you go." – Amanda
>
> "I would just say, it's basically [the lecture course] but they go more into depth, and it helps I guess to like help solve any confusion, you may have." – Rachel
>
> "It's very interactive. Like the teacher is really good. And I think it's very like, the pace is good, and like the homework amount is perfect." – Gloria

The students characterized the corequisite course as a venue for "tutoring" and to learn more about the course content. From these characterizations, it appears that students found the course to be a helpful supplement to their College Algebra lecture. In the following sections, I will highlight specific elements of the corequisite that students found positive and others that they found negative.

Benefits of the Corequisite

Corequisite interviewees and survey respondents were asked to highlight some positive aspects of their corequisite course. Ironically, even students who felt like they should not have been placed in the corequisite highlighted the benefits of the course. Emmanuel shared in the Week 16 reflections, the most effective aspect of the corequisite for him was simply "taking notes and showing up to class." Being present and engaging was beneficial for him, even though he originally rejected being placed in the corequisite course. Two topics emerged from student responses related to the benefits of the corequisite course, they included *positive attributes of the instructor*, and how *the corequisite prepared them for their lecture course*.

Positive Attributes of the Instructor

Ten of the corequisite students (all corequisite interviewees and three SPIPS respondents in the open responses questions) elaborated on positive attributes of the instructor that made their experience beneficial. Chih-Wei stated, "so I think the professor is caring, like you know she wants you to succeed." Such sentiments were echoed in all the corequisite student interviews. Isbelia shared,

> I don't like talking in class because I have a fear of it, but she makes me feel comfortable because like I said she doesn't put me down, make me feel stupid like my other teachers have made me feel stupid.

As explained earlier, students enter the classroom with a variety of learning experiences, some negative, some positive. Isbelia had a negative experience learning math, where her interaction with previous instructors caused her to question her mathematical ability and potential. In this quote she highlighted how antithetical the relationship she had with Ms. Addison was to that of her previous math instructors. Because of the tone set by Ms. Addison in the corequisite course, Isbelia felt more comfortable participating, and Chih-Wei felt academically supported. Bandura (1997) identified *verbal persuasion*, as a source of self-efficacy. Verbal persuasion refers to the idea that an influential figure in a student's community can affect the way a student perceives their ability. The interaction between Isbelia and her previous math instructors led her to feel less capable of succeeding in mathematics whereas the experience with Ms. Addison has helped Isbelia rebuild her sense of efficacy around learning mathematics.

In some interviews, students contrasted their corequisite instructor to their lecture instructor. Gloria stated,

> I feel like for [the College Algebra lecture], it's more like okay, you're here to like lecture, lecture, lecture. And then [the corequisite], like Ms. Addison gives like a better … I don't know, like her vibes and her way of teaching is a little bit more peppy.

Ms. Addison's "peppy" personality set the tone for the class environment. Students entered the virtual corequisite classroom with a different mindset than they would their lecture course. Specifically, students like Gloria entered the corequisite course feeling calmer and more relaxed whereas they felt their lecture course was more serious and focused. This difference in perception may have affected which instructor students approached for extra help with course content. For instance, Adriana explained,

> I would, for sure attend my [corequisite] office hours, just because I felt a lot more relaxed and comfortable with her just because she knew that she was there to help us with the [lecture] class, so I was just more comfortable going to her to ask for help.

So, not only did Ms. Addison's personality make Adriana feel more comfortable approaching her for help, but the nature of their relationship reinforced this decision. Adriana perceived her instructor as someone positioned to help her, thus if she needed additional support on course content and was deciding which instructor's virtual office hours to attend, she would naturally gravitate to Ms. Addison's virtual office hours over Ms. Johnson's.

This decision to attend one instructor's office hours over another seemed more to do with the students' perceptions of the nature of their relationship with their instructors. Like Adriana, Gloria also explained that she would attend Ms. Addison's office hours over Ms. Rose's:

> Like Ms. Addison has more of like a vibe, where you can like ask her anything and it's fine and then Ms. Rose is more ... she's still a really good teacher and I don't have like anything like that's been confusing in her class because everything that she teaches is good, but like I think [the corequisite] is more for problems that you have questions with and [the lecture course] is just so you absorb everything from the lecture. And then if you have any questions, go to [the corequisite].

Some students based their decisions on whom to approach for help on the perceived distinct purposes of the corequisite and lecture courses. As they described earlier in this section, the corequisite course is for "tutoring" and the lecture course is more "intense" (as characterized by Chih-Wei) with the primary purpose of "lecture, lecture, lecture" (as described by Gloria). Thus, some corequisite students may primarily attend Ms. Addison's office hours because she is positioned as a tutor, or as a person who provides additional help. Even so, there were some students that identified their lecture instructor as the person they would approach for extra help. Chih-Wei declared that he would attend Ms. Martinez's office hours, "since she's [his] main professor."

The Corequisite Prepared Students for the Lecture

All corequisite interviewees but one (Adriana) described how the corequisite course prepared them for their lecture course. This point aligned directly with the purpose of the corequisite course as outlined by the instructional leaders; the purpose of the corequisite course is to support student learning of lecture material. The logistical timing of the course, 9:00am before every lecture section, was important for getting students acquainted with the core language and ideas that they would encounter later in the day. This is something that many of the students appreciated, including Jeffrey who said,

> So, it's like I get like a preview of it in the morning and then whenever we're discussing again in the afternoon it's like oh yeah that makes sense. You know, I feel like, I am more prepared because it's not like I'm going in like, I have no idea what we're talking about.

The morning preview of lecture material helped situate students into the course content. Jeffrey felt more prepared for the lecture material because he received an introduction in the corequisite. The corequisite course helped ensure that students were prepared for the lecture course and were aware of the prerequisite skills needed to approach the lecture tasks.

The corequisite course not only prepared students for their upcoming lectures, but it also prepared them for their College Algebra assessments and activities. Chih-Wei shared,

> I really think the [corequisite] class helped me a lot because it's just like an extra class that assigns you like more homework, like the one of those that's optional for [the lecture class]. I think it's pretty helpful when you actually do it. And another thing is the Fridays, I think we have a review session, which is also really good it really helped me to win for the quizzes and tests.

Some of the tasks assigned to the corequisite students were optional practice assignments given to all College Algebra lecture students. Chih-Wei found benefit in completing these assignments, as they provided extra practice of lecture content. He also spoke about the Friday corequisite classes, which were review days that were mostly student driven. The instructor would open the Zoom room for student questions around any emergent topic. Since many Fridays for the lecture class included an assessment (either individual quiz or group quiz), the corequisite students preferred that Ms. Addison reviewed material relevant to the assessment they would take later in the day.

Drawbacks of the Corequisite

For the most part, students reported having good experiences in their corequisite class, and as described in the previous section, they found that there were many benefits of having the additional support. Even so, there were two topics related to negative experiences that arose in all interviews and some open responses in the weekly reflections: *the corequisite at times was repetitive and time consuming*, and *groupwork was not always productive*. One additional student complaint, that did not fit nicely in any of these categories but is worth including, was around the types of problems Ms. Addison chose to review. In the Week 16 reflections, Sonia (a corequisite student not interviewed), listed "sometimes not going over harder problems that might be on the quiz or group exam," as something that was ineffective in the corequisite course. She did not feel the level of rigor expected in the assessment aligned with the type of review Ms. Addison conducted during the Friday sessions. She felt that Ms. Addison chose easier questions to review than the questions that they encountered in their lecture assessments.

This sentiment was not universal. Chih-Wei praised the review sessions and shared that they helped him "win for the quizzes and tests." Likewise, Jeffrey mentioned, "[Ms. Addison] gives examples of problems that are kind of worded maybe similar to how the quiz are going to be worded. So that's been a big help for me." These conflicting accounts of the review sessions is an important example of why we need to canvass all students to learn about what is working and what is not working for them. Sonia's complaint may have been a valid complaint or a reflection of a disconnect in her understanding of the course material. Thus, more dialogue is needed in fully supporting students' academic growth.

The Corequisite is Time-Consuming/Repetitive

Four corequisite students complained that the corequisite course was time-consuming and at times repetitive. For Adriana and Rachel, they simultaneously disliked how repetitive some aspects of the class were and understood the rationale for the repetition. For example, Adriana stated "[Ms. Addison] gave a lot of repetitive work from [lecture] which I understood, because you know, practice and stuff … but yeah it was really time-consuming." Rachel felt the same way and highlighted that at times the homework for the corequisite course was essentially the same thing for the lecture course.

> That homework usually is the same as the [lecture] homework. And usually, it's the same questions. Well, for me, they are same questions, but for other people it's the same questions with different numbers. So, I just don't like that because then it's just like repeating or just inputting the same answers.

Though Rachel did see the benefit of having additional practice problems, she did not see the benefit when the problems were the same as her lecture assignments.

In the Week 9 reflections, Jasmine, another corequisite student (not interviewed), addressed the time-consuming nature of the corequisite work as something that has not been effective for her learning during the semester. She positioned "assigning four homework assignments for one class when I have so much other stuff to do for other classes and math lecture" as something that was not working well. The "four homework assignments" that she was referencing was the assignments that corequisite students needed to complete for both the lecture and corequisite course. The additional workload that accompanied the corequisite course was an inconvenience for her given her academic load. Along the same lines, Chih-Wei questioned the number of units granted for the corequisite course with respect to the workload, "I don't know if one credit is a lot but it's basically this at the same time. It's all, it's both 50 minutes … the [lecture course] and the [corequisite]." Chih-Wei recognized that both his lecture and corequisite course met for the same amount of time each week, but one course offered three units and the other one unit.

The corequisite course and the lecture course sections were scheduled to meet for the same number of hours per week, yet the lecture course granted three units and the corequisite only granted a single unit. Thus, the corequisite students were putting in at least twice the amount of work and class time towards learning College Algebra than their non-corequisite peers but were only receiving one additional unit of credit. Chih-Wei added, “If [an] incoming student is not like confident … then I’ll definitely suggest them to take the [corequisite] class, but then, if they're like semi-confident, … then maybe, just take another course or something like that.” He provided this response after being asked whether he would recommend the corequisite class to an incoming student. While he did see the value in the corequisite course, the added time commitment made him question whether it was worth receiving a single unit of credit. He ultimately recommended the corequisite course for students who were not at all confident in their mathematical abilities.

Groupwork in the Corequisite Course Was Not Always Productive

In Chapter 5, I explained that students in the corequisite course worked in breakout rooms (37% of the observed class time) more often that their students in the lecture course (average 6.4% of the observed class time). When asked to reflect on what has not been effective in the corequisite in the Week 9 reflection survey, Fernando (not interviewed) simply stated “breakout rooms.” Three of the corequisite interviewees also mentioned having a negative experience in the breakout rooms in their corequisite course.

Amanda expressed concern about other students explaining concepts to her. She stated,

> I usually ask them ‘can you double check my work?’ … And they would double check it and then they tell me what they think it is. And it’s a little hard when they try explaining it to me though. Because … I don't fully understand fully about their work and everything.

Whenever Amanda’s groupmates attempted to help her understand the mistakes she made while working in groups, she would get confused with their reasoning. While working in groups did provide opportunities to learn from peers, it also led to instances of communication breakdowns and unproductive collaboration. This episode with Amanda is an example of when an instructor is needed to help ensure that all students are getting the most out of their classroom experience, and not leaving the environment with unanswered questions.

Isbelia had an opposite experience working in groups, “um, me personally I like groups if I don't understand the material. But if I do understand the material, I like working by myself because I feel like I get more done.” She enjoyed interacting in groups where she learned from her peers, but in instances where she knew the material she preferred working alone. Thus, it seems that Isbelia only liked working in groups when she felt like she was getting something out of the experience. In this vignette, Isbelia was unable to see herself in her peers that needed help in problem solving. Particularly, she did not recognize that she was at times that student who needed the additional support. She also did not see the value of the discourse that resulted from explaining your reasoning to her groupmates. This is an example where an instructor articulating the purposes of groupwork is essential before sending students to collaborate. If the goal of the activity is to simply complete the assignment and get the correct answer, it is natural for students to become annoyed by having to help their peers instead of completing the assignment on their own.

Jeffrey’s complaint about groupwork was somewhat similar but it was more related to the overall division of labor while working on class assignments in the breakout groups.

> There was one instance where I was in a breakout room, and it was like nobody did anything but me. So, it was like I did all the work. And I was like, trying to get other people involved, like, Hey, do you guys know what to do here. And like one of the people responded ‘No, I don't.’ And then it is just like the other two, they just didn't do anything.

In this instance, Jeffrey was the only person in his group of four who was actively contributing to the class assignment; two of the students were disengaged and one student did not understand what was going on. Like in Amanda’s example, this would have been an opportune time for Ms. Addison or an undergraduate learning assistant (ULA) to intervene and provide necessary support to prevent Jeffrey from being the sole contributor to the group discourse. The fact that only one student was willing/able to engage with the task is evidence that more scaffolding may have been necessary before commencing the activity. However, Jeffrey later clarified, “but yeah, it was just that one instance.” He explained that this was not a common experience for him working in groups in the corequisite course.

Climate and Inclusion in the Corequisite Course

When the corequisite interviewees were asked about their perceptions of the classroom climate, one student (Rachel) characterized the environment as “cold” while the others characterized it as “chill” or “mellow.” Rachel elaborated, “the class is kind of early, so I feel like everyone is just very quiet and they're just like waiting for class to be over with.” She characterized the class as “cold” because students were quiet while working in the whole class setting. During these times, students would participate primarily through chat and the only voice that could be heard is that of the instructor. Rachel continued, “the professor tries to include all of us, but since like I said it's an early class, all of us are just quiet.” Thus, even though Ms. Addison tried to engage students in whole class discussions, students were reluctant to unmute in this venue and chose to participate primarily in the Zoom chat.

The other corequisite interviewees characterized the classroom climate as “positive, “open,” and/or “chill.” Amanda responded, “I would say [the climate] is pretty good. Everyone seems almost positive, people are a little tired, but pretty positive”. Like Rachel, Amanda noticed that her classmates seemed quiet in the morning, and she attributed that behavior to everyone feeling tired. But overall, she interpreted her environment as positive. Jeffrey explained, “I think that just the environment in the classroom is not as like being judged or somebody is better than somebody, you know … It's just feels like an open environment." He described the classroom environment as a place where he felt open to contribute and unafraid to make mistakes.

Chih-Wei characterized the classroom climate as "chill." He explained that on days with group activities, "you can just talk to people after you're finished stuff like, … it was really helpful since we're all virtual now and then you can really get in touch with people." Chih-Wei felt comfortable interacting with his peers in the breakout rooms even after completing assignments. This community building was important for him given the virtual nature of the classroom. In addition, since he was logging into his classes from Taiwan, this was one of the few opportunities he had to connect with his GSU peers. This feeling of community and mutual support was mentioned by all the corequisite interviewees. Adriana stated,

> I think about the [corequisite] course, I really liked how overall how helpful everyone was. So, like they understood that not everyone is the best with math, and you know, like everyone learns differently, especially online. So, everyone was really understanding and just like, I think really just flexible overall because they know like not everyone is in the same position, you know, so I really like that.

Through collaboration in breakout rooms, students were able to support each other in the virtual space. Though there were instances where groupwork could have been more productive, students overall reported positive experiences collaborating with their corequisite peers. As Adriana and Jeffrey put it, there was minimal judgment and mutual recognition of the diversity of understanding within the class. Ms. Addison created an environment where students felt comfortable participating and seeking help when needed, whether it was from her or from classmates.

Student Affect in relation to their College Algebra Classes

In this section, findings related to the third theme around student affect are discussed. *Student affect* refers to the emotions, attitudes, and values towards learning (Nieswandt, 2007;

Popham, 2009) – and in this context, learning and doing mathematics. I begin by highlighting student affect in response to the corequisite course. I then discuss the College Algebra students' propensity for seeking help, since this is related to their values about what they deemed as helpful towards their learning. Recall, there were many students in the College Algebra lecture who should have been placed in the corequisite, so understanding the greater population of students was important for this study. In the final three sub-sections, I discuss the College Algebra student responses to affect-related survey items in the SPIPS. Specifically, I discuss student values around helpful classroom structures, their attitudes towards doing and learning mathematics, and finally, their beliefs about learning.

Student Affect in response to the Corequisite

From the previous section we see that students were getting a lot out of their corequisite course. The corequisite prepared them for the coursework in the lecture class, and the corequisite instructor helped support student learning and motivated more students to engage with the material. There were also some downsides to the course; the corequisite required a greater time commitment, it was at times repetitive, and students did not always feel that the collaborative activities were productive. Nevertheless, corequisite students (Amanda, Isbelia, and Jeffrey) reported having a greater understanding of math because of their experience in the corequisite. Isbelia shared,

> I feel like I have gained so much knowledge in math and I am so proud of myself. I have never been proud of myself in math. So, I'm really glad that I'm passing this class right now and the professor has been a big help. The [corequisite] support has been such a big help as well.

Recall, Isbelia previously had negative experiences learning mathematics and as a result she did not believe she was good at math. She credited her success in this course on both the corequisite instructor, who was also her lecture instructor, and the corequisite class in general.

Amanda and Adriana reported that they became more organized because of the corequisite course. Amanda explained that she became more organized because "[the corequisite] tells me what I am doing … and makes sure I'm prepared for it and knowing what I'm going to do and what I need to do." Amanda reiterated that the corequisite course helped in her preparation for the lecture course, and thus in general helped her become more organized in her studies. Adriana shared,

> From the [corequisite] course I think I was able to like, just kind of be more organized with my work. Just because I knew I would have a lot coming for this week, and not just from those two classes. So, I was like … Okay, I need to get this done before this day. So, I definitely became more organized and like I knew when to get things done. And yeah, that was honestly like the biggest thing that really did it for me like it just made me a lot more organized with my work.

Adriana's biggest complaint about the corequisite was that it was time-consuming and repetitive. When asked if she would change anything about the course, Adriana listed the homework as being a major classroom device that needed to be fixed. Ironically, because of the additional homework that accompanied the corequisite course, Adriana reported developing better organizational skills to manage the workload in all her classes.

There were mixed responses when the corequisite students were explicitly asked to measure the effect the corequisite course had on their affective states. For some, including Adriana and Rachel, the corequisite did not have any effect on their confidence, perceptions of efficacy, nor their interest in doing and learning mathematics. Adriana shared,

> Honestly, it didn't really affect like my interest in math at all, it's kind of just remained the same. I was like I know I'm not the worst at math, but I definitely could … improve in it. So, I don't know, it's kind of just stayed the same, for me, honestly.

Adriana also added that the course did not have an effect on her confidence in her mathematical abilities. She clarified that these responses were not a criticism of her instructor, but rather it is about her own personality. Her relationship with mathematics was unchanged by the corequisite course. For context, Adriana began the course as an Environmental Engineering major and by the end of the course she was considering undeclaring that major. She explained,

> It's mostly kind of me just overthinking right now, just because, like I'm like I don't know if I really want to go in that field. So yeah, I don't know I'm kind of just going with the flow right now to see what's calling my interest.

Adriana was navigating her first semester of college, and the global pandemic did not make matters any better. Though she did benefit from the course, it did not have significant effects on her attitudes towards mathematics.

Amanda, Isbelia, and Gloria reported that they felt more confident in their mathematical abilities because of the corequisite course. Isbelia specified that she now “feels more confident in [her] algebra skills.” Gloria linked her newfound confidence to her projected course grade, “since I have like a good grade in it, it's like making me think, oh, I am actually good at math.” These students’ successes in mathematics during the semester, which are by definition enactive mastery experiences (Bandura, 1997), led to them experiencing a greater sense of efficacy in learning and doing mathematics.

Amanda explained that in addition to her increased confidence in her mathematical abilities, she also became more comfortable participating in the virtual classroom. She shared, “[the corequisite] is getting me to be more confident as I was having a hard time before. But I am more willing to talk more and explain why I got my answers.” Since students spent a lot of class time working with groups, being able to communicate your reasoning was an important skill that students needed to have in order to fully engage with their peers. At the start of the semester, Amanda reported some negative experiences working in groups where she could not understand how her classmates arrived at their answers when they tried to explain it to her. By the time of her interview, which occurred during the 10th week of the semester, she developed greater confidence and felt more comfortable interacting with her peers during group activities.

Lastly, several students (Isbelia, Chih-Wei, Amanda, and Jeffrey) expressed a greater interest in doing and learning mathematics as a result of their corequisite class. Chih-Wei and Jeffrey described feeling a sense of euphoria when solving problems after understanding the concept. Chih-Wei stated, "once you solve more, you're like … hey I know this, I can do good." Similarly, Jeffrey explained, "it's like, and I kind of can't wait to do some of this work because I understand it now." Enactive mastery experiences is the strongest source of self-efficacy amongst learners (Bandura, 1997). Being able to understand the material directly affected these corequisite students' interest in doing the mathematics. This sentiment was echoed by Amanda who described how she went from not liking math at all to starting to like it:

> It's getting me to like math more because I didn't really like math. So now, I kinda like it a little bit more … Because like it's getting easier for me. Before it was so hard. Now, it's slightly easier and I'm pretty sure it will get easier as more time goes by.

Like many other corequisite students, math was not a favorite subject for Amanda, and it was something she struggled with previously. The corequisite course pushed her to rethink her relationship with mathematics, and she now thinks positively about her potential for understanding mathematics as she continues forward along her STEM pathway.

As previously discussed Isbelia had a negative relationship with mathematics, and it caused her anxiety after recognizing the relationship between mathematics and biology, the area she is interested in pursuing. She shared,

> I know with science, I always knew I wanted to do something in science, but I also knew science also relates with math. So that kind of like put me down. And I was like, I suck at math. And like I just, I won't be able to go the science route, but I finally understand. Again, I'm like, Okay, yes, this is what I want to do, like, I'm very happy with it. Like I don't dread math anymore. Like I come in. I'm like, okay, like I know what I'm doing. Like I can get all my work done on time.

The corequisite course had a great impact on students like Isbelia, who entered with an aversion to learning and doing mathematics. The *I suck at math* mindset is harmful and can thwart many

STEM-intending students from proceeding along a STEM pathway. The corequisite course helped students like Isbelia dismantle their fear and anxiety around mathematics and provided a way for greater understanding of prerequisite knowledge for successful course outcomes in the College Algebra lecture course.

Student Propensity for Seeking Help

Unlike the other College Algebra students, the students enrolled in the corequisite course had the corequisite as a venue for seeking further clarity on College Algebra course content. At the beginning of the semester, the College Algebra lecture instructors assigned a Scavenger Hunt project so that lecture students could learn about the student support services available on campus. Given the global pandemic, this assignment was more important than in previous semesters since it may have been unclear to many students whether campus tutoring centers and academic support centers were still available at their disposal. This scavenger hunt required students to determine the hours of operation of GSU's Mathematics Support Center, identify a time in their schedule where they would be able to seek tutoring at the center, and have a documented meeting with a tutor to introduce themself. This activity was one way to showcase the many ways that students could seek help during their first full semester of virtual learning.

On the SPIPS, all College Algebra students rated how often they sought extra help outside of the classroom along a Likert Scale from Never = 1 to Always = 5. On average, students rarely sought tutoring (M = 1.87, SD = 1.043) or help from the instructor (M = 1.77, SD = 1.054) outside of class time. When asked where they did seek help in those rare instances, students identified the various venues as highlighted in Table 6.4. It is worth noting that 19 of the students documented using the Mathematics Support Center for extra help. Thus, the Scavenger Hunt assignment potentially was helpful in the long run. However, many students either did not seek extra help (48) or relied on friends and family for academic support (44). Consistent with the vignettes from the corequisite student interviews, six of the seven corequisite survey respondents identified their corequisite course as a place where they sought extra help. This is consistent with the characterization of the corequisite course as a venue for tutoring.

Table 6.4. Where students go for help.

	Non-corequisite Students	Corequisite Students
Corequisite Course	-	6
Mathematics Support Center	17	2
Instructor’s Office Hours	16	2
Friends and Family	44	7
Private Tutor	6	2
Optional Friday Review Sessions	8	5
Internet	4	0
MyMathLab Videos	2	0
I have never asked for extra help or tutoring	48	2

Student Values around Helpful Class Structures

On the SPIPS, the College Algebra students shared perceptions of classroom practices that were helpful for their learning by rating them along a five-point Likert scale from “Not at all helpful” (rating of one) to “Extremely helpful” (rating of five). On average, they identified four classroom structures that they determined as very helpful: the instructor guiding students through major course topics (4.56), receiving immediate feedback from the instructor on work during class time (4.15), being able to work on problems individually during class time (4.09), and receiving feedback from the instructor on homework (4.21). Earlier in the chapter I demonstrated that “Listening to the instructor lecture or solve problems” and “Working on problems individually” made up the larger portions of class time. Together these categories made up at least 57% of class time across lecture sections and the corequisite course. Hence, there was alignment between student values as reported in the SPIPS and their lived experiences in these courses.

What was Helpful for the Corequisite Students?

An independent samples t-test was conducted on the 18 SPIPS items around helpful classroom structures, to determine whether there were statistically significant differences between the seven corequisite student respondents and their 110 peers. Given the number of t-tests conducted, and to control for potential Type 1 errors, a Holm-Bonferroni adjustment was made in computing *p*-values. Along a five-point Likert scale from "Not at all helpful" (rating of one) to "Extremely helpful" (rating of five), there was not a statistically significant difference between the two groups of students on most of the helpfulness survey items about the College Algebra lecture experience. However, the corequisite students positioned Group activities as more helpful ($M = 4.71$, $SD = 0.756$) than their non-corequisite peers ($M = 3.29$, $SD = 1.429$); this finding was statistically significant $t(9.015) = 4.496$, $p = 0.001$. Similarly, the corequisite students positioned working with other students in small groups as more helpful ($M = 4.71$, $SD = 0.756$) than their non-corequisite peers ($M = 3.53$, $SD = 1.318$); this was also statistically significant $t(8.529) = 3.803$, $p = 0.005$.

A post-hoc analysis revealed a statistical power of about 70% in comparing the corequisite and non-corequisite students. Thus, the threshold for a potential Type II error was about 30%, which is above the acceptable 20% value. Even so, these findings aligned with what was observed in the different classroom environments between the corequisite and the lecture courses. The corequisite students spent a larger share of their class time working in small groups, thus they were more familiar and eventually more comfortable with this classroom structure. As Jeffrey mentioned in his interview,

> Yeah, I think [group activities] helps out at least for me because I'll be like, well, I don't understand this part or … maybe somebody else can help me with reinterpreting the question. Like what does it want us to do here. And someone might say, oh, you know, it wants us to do this. And I am like, Okay, well then, I know what to do. And then just working together as a group kind of helps because you can bounce ideas off of each other or maybe you mess up and forget a negative and somebody else comes behind you and checks your work … and then so you just kind of help everybody out as a group.

As Jeffrey explained, working in groups in the corequisite course provided students an opportunity to seek clarification and to bounce ideas off each other. This environment allowed students to support each other's learning and to evaluate each other's work.

What was Unhelpful for the College Algebra students?

The non-corequisite students' relatively lower preference for collaborative work was echoed in the open responses in the SPIPS survey around what was unhelpful in the lecture course. Out of the 99 respondents to this open prompt, 33 (1/3 of respondents) expressed complete dissatisfaction for group activities in the lecture course. One non-corequisite student commented,

> I don't think group activities/quizzes are very helpful because in my experience no one ever even communicates in there. People get into the breakout rooms stay muted and do their work individually. Even when people need help, they typically wait until the teacher comes into the room to check on us to ask.

In other words, whenever students were brought together to work collaboratively, students chose to or were stuck working independently. They did not seek help from their groupmates and relied heavily on their instructors to address their questions. One corequisite student, Jeffrey did report on experiencing this kind of behavior in his corequisite class during one activity. But he later clarified that only occurred once throughout their time working collaboratively in the corequisite course.

Four of the 110 non-corequisite survey respondents expressed that group activities were not always helpful, but they saw the potential for the experience to be beneficial to their learning. For instance, Paige wrote,

> Group work has its benefits and negotiation of meaning is a benefit pedagogically but attempting to learn Jamboard or Google docs, upload, operate under a time restriction, having to submit a survey to comment on partners, even get to partners to actually work together.... I could go on – this isn't working. The stress alone of trying to participate in the groupwork this way (on top of everything else going on right now) was too much for me some days and I had to choose my mental health over receiving points.

This student recognized the potential benefits for collaborating with their peers but from their experience, these benefits were not actualized. For this student, and perhaps many others, the social and technological hurdles got in the way of the potential benefits of these activities in the lecture course.

In contrast, six of the seven corequisite survey respondents explicitly elaborated on the value that collaboration with their peers had on them. In the SPIPS survey prompt asking about what was unhelpful in the lecture course, two of them wrote the following:

> Corequisite student 1: Doing group projects helps; we can help each other when doing so.
>
> Corequisite student 2: The breakout rooms really help me because me and my classmates talk amongst ourselves.

These students ignored the prompt about sharing what was unhelpful to share the value they saw in collaborative learning. These students valued the opportunity to collaborate with their peers through groupwork. Corequisite student 1 emphasized that through groupwork, they can support each other’s learning. These statements echoed the corequisite students’ earlier positioning of small groupwork and peer-to-peer interactions as beneficial to their learning experience. Since the corequisite students spent a lot of time engaging with their peers in breakout rooms in their corequisite course, it is not unreasonable to assume that those experiences colored their perceptions of their lecture course activities.

Lastly, four of the corequisite survey respondents broadly suggested, in their commentary on what was unhelpful, that everything they experienced in their courses were helpful. For instance, one corequisite student elaborated,

> There had been nothing to be found not helpful. I believe that any kind of resource that is provided for us is a perfect way to practice the material that we are learning, and any kind of practice provided on any platform is helpful. Projects and class activities are especially helpful to work with others to understand the topic.

This student had an overall optimistic outlook on their learning experience. They appreciated all the learning supports provided to them throughout the semester, while also highlighting how working with others on group activities was helpful for their learning.

Shift in Attitudes

Despite the mixed sentiments about certain classroom structures (e.g., group activities), students reported positive changes in their attitudes toward learning and doing mathematics on the SPIPS (see Table 6.5). The College Algebra students rated their attitudes from the start of the semester to the end of the semester on a five-point Likert scale. A paired samples t-test revealed a (Holm-Bonferroni corrected) statistically significant increase in the College Algebra students' enjoyment in doing mathematics and confidence in mathematical abilities, and a statistically significant decrease in anxiety towards working with others. Thus, regardless of their experiences working in groups (whether positive or negative), on average, students did report experiencing less anxiety and they felt more confident in their mathematical abilities. Given Paige's earlier recount of her experience working in groups, it is important for instructors to create safe and productive spaces for students to feel comfortable and supported in working with their peers.

Table 6.5. Changes in College Algebra students' attitudes towards mathematics.

	Paired Differences				
	Mean	Standard Deviation	*t*	*df*	*p*
I am interested in mathematics	0.026	0.933	0.297	116	0.383
I enjoy doing mathematics	0.214	0.927	2.494	116	0.007*
I am confident in my mathematical abilities	0.291	1.009	3.115	116	0.001*
I am able to learn mathematics	0.162	0.754	2.33	116	0.011
I feel anxious when working with others on math	-0.265	0.835	-3.434	116	0.0004*

Note. N=117 for all tests. Statistically significant values are starred *.

There was a difference between the corequisite students and their peers on these attitude survey items. As seen in Table 6.6., the corequisite respondents reported experiencing a greater change in attitudes across all five measures than their non-corequisite peers. Corequisite students reported a greater increase in interest, enjoyment, confidence in mathematical abilities, and perceptions of ability to learn. They also reported a greater decrease in anxiety when working with others on math. Though only seven corequisite students completed the SPIPS, their responses coincided with the qualitative analysis of the interviewed corequisite students. These students highlighted that from their experience in the corequisite course they felt more confident working in groups, more confident in their abilities, and had an overall better understanding of the material. However, using an independent samples t-test, a statistically significant difference between the corequisite students and their peers in response to these affect items on the SPIPS was not found. Post-hoc analyses revealed low statistical power in comparing the corequisite and non-corequisite students.

Table 6.6. Attitude changes by support status.

	Support	N	Mean	Std. Deviation	*p*
Difference in Interest in Mathematics	Non-corequisite	110	0.000	0.938	0.209
	Corequisite	7	0.429	0.787	
Difference in Enjoyment in Doing Mathematics	Non-corequisite	110	0.182	0.921	0.195
	Corequisite	7	0.714	0.951	
Difference in Confidence in Mathematical Abilities	Non-corequisite	110	0.273	1.004	0.519
	Corequisite	7	0.571	1.134	
Difference in Perceptions of Ability to Learn	Non-corequisite	110	0.136	0.735	0.288
	Corequisite	7	0.571	0.976	
Difference in Anxiety in Working with Others	Non-corequisite	110	-0.218	0.806	0.085
	Corequisite	7	-1.000	1.000	

Shift in Beliefs about Learning

As we have seen, the Fall 2020 semester of virtual learning brought positive shifts in attitudes toward mathematics for the College Algebra students at GSU. Like with the attitude SPIPS items, students rated their beliefs about learning from the start of the semester to the end of the semester on a five-point Likert scale. A paired samples t-test, with a Holm-Bonferroni correction, revealed a statistically significant increase in two of the ten items. As displayed in Table 6.7, there was an increase in student perceptions of the importance of making sense out of mathematical approaches before being able to use them ($t(116) = 3.581$, $p = 0.0003$), and their beliefs around persisting in problem solving when a problem arises that they cannot immediately solve ($t(116) = 2.517$, $p = 0.007$). Both the corequisite students and the non-corequisite students reported increases along these survey items, and there did not exist a statistically significant difference between the two populations. Like in the prior analysis, a post-hoc analysis of statistical power revealed low statistical power for determining differences these groups of students.

Table 6.7. Changes in students' beliefs about learning and understanding mathematics.

	Paired Differences				
	Mean	Standard Deviation	*t*	*df*	*p*
I can learn from hearing other people's thinking, even if it is not correct.	0.111	0.584	2.058	116	0.021
I cannot learn if the teacher does not explain well.	0.009	0.663	0.139	116	0.555
When a question is left unanswered, I continue thinking about it afterward.	0.034	0.681	0.543	116	0.294
Nearly everyone is capable of understanding math if they work at it.	0.009	0.609	0.152	116	0.440
To understand math, I discuss it with other students	0.060	0.606	1.068	116	0.144
I do not spend more than 5 minutes on a problem before giving up or seeking help.	-0.137	0.899	-1.645	116	0.949
Understanding math means being able to communicate your reasoning to others.	0.068	0.486	1.520	116	0.131
It is important to make sense of mathematical approaches before I can use them.	0.162	0.491	3.581	116	0.0003*
When a math problem arises that I can't immediately solve, I stick with it until I have made progress.	0.171	0.735	2.517	116	0.007*
I enjoy figuring out math problems with other people.	0.026	0.713	0.389	116	0.349

Note. Statistically significant values are starred *.

Discussion

In this chapter, students' experiences in the College Algebra corequisite course were highlighted by attending to their beliefs around their placement, their accounts of the experience in the lecture and corequisite support courses, and their perceptions on the effect of the corequisite on their affective states. Students reported benefitting from enrolling in the corequisite course though they identified areas for improvement (e.g., the corequisite was at times repetitive and time-consuming). In this final section, I discuss the findings around the main research themes of *placement*, *virtual engagement*, and *student affect*. These themes, though separate, influence each other. I began this chapter with a discussion on placement and virtual engagement. The first and second themes were important in contextualizing the student experience and understanding student affect within the corequisite environment. I conclude this chapter with a discussion of the third theme and by answering the focused question, *how are students' interests, beliefs, and attitudes around mathematics and mathematics learning affected through enrollment in the corequisite course?*

Discussion on Placement

Placement into the corequisite course was a huge problem identified by both the students and institutional leaders at GSU (see Chapter 4). For instance, due to some institutional oversight, Rachel was recommended to take the corequisite course even though she placed out of the course and into the Pre-Calculus course using GSU's skills assessment exam. Similarly, there were students in the corequisite course that did not need the added support but were placed there based on the Chancellor's placement system. It is likely that the opposite occurred for students in the lecture courses, where due to flaws in the placement system some students were not placed in the corequisite course though they needed the added support. In fact, Ms. Martinez shared in Chapter 4 an instance where one of her lecture students needed the corequisite support, so she invited them (unofficially) to attend the corequisite course. Therefore, it was essential for me to understand the student experience in both the lecture and corequisite support courses, recognizing that there were students who needed the added support but were not provided it. In addition, the corequisite student experience was influenced by both these courses, and thus to understand the student experience requires a closer look at both contexts of learning. Any insight about the student experience in either course can potentially lead to changes in both the lecture and support courses given GSU's College Algebra instructional team's mission to coordinate their College Algebra lecture course sections and corequisite courses.

Discussion on Virtual Engagement

The descriptive and statistical findings from the SPIPS demonstrated that, on average, all students (corequisite and non-corequisite students alike) valued when instructors guided them through course topics, when the instructor provided immediate feedback during class time and on homework assignments, and when they were able to work on problems individually during class time. The corequisite students reported a statistically significant greater value of helpfulness to group activities and working in small groups than their peers – this coincides with their experience of more collaborative learning in their corequisite course. Even so, corequisite and non-corequisite students both reported instances where group activity was not as productive as intended. A common complaint about group activities, though not universal among the corequisite students, was that students were working independently instead of collaboratively and that everyone was not engaged in the activity.

To avoid these situations, it is important that a culture of collaboration is first established in the classroom. When a classroom norm is set, and students are in the mindset to work with their peers, there tends to be less resistance to doing group activities. For example, corequisite students were accustomed to working with their peers. Hence it was unsurprising when these students identified (in the interviews and the survey) group work as a benefit of their corequisite experience. Second, in addition to establishing these classroom norms, it is also important that instructors highlight the purpose of collaboration. Isbelia, a corequisite student, enjoyed working in groups when she needed help and could ask her peers for assistance. When she knew the material, she preferred to work independently. By fostering a culture of mutual support, rather than a culture where students are collectively completing assignments, students would be more willing to engage in dialogue in supporting their peers rather than simply trying to complete an assignment.

Lastly, students must be fully equipped to engage with the task before they are required to work in groups. Jeffrey, a corequisite student, shared an example of a time when he was working in a group with three other students, and he was the only one who understood the task and was actively participating. These instances may occur when students are not given adequate tools to engage with the task environment beforehand, and the activity as presented is perceived as confusing or overwhelming. As Jeffrey explained, there were instances where he did not understand the wording of the activity, so he relied on his groupmates to explain it to him. Once he understood the problem context and statement, he was able to do the work. Thus, it is important that students are thoroughly prepared for engagement in group activities before they are expected to engage productively with each other in a collaborative learning setting.

Discussion on Student Affect

So, *how are students' interests, beliefs, and attitudes around mathematics and mathematics learning affected through enrollment in the corequisite course?* Based on the findings from the SPIPS, there was not a statistically significant difference between the corequisite students and the non-corequisite students on the survey items related to student affect. Even so, corequisite students reported an increase in interest, enjoyment, confidence in mathematical abilities, and perceptions of their ability to learn mathematics from the start of the semester to the end. They also reported a decrease in anxiety when working with their peers on mathematics. This finding was consistent with the collaborative nature of the corequisite course. One limitation of the SPIPS findings is that only seven of the corequisite students completed the survey and thus, statistical power was low. However, these findings were corroborated by the qualitative data obtained from student interviews and classroom reflections from all corequisite students.

There were two sources highlighted that contributed to greater self-efficacy beliefs of the corequisite students. Enactive mastery experience, which Bandura (1997) characterized as the strongest source, made students feel more confident in their abilities to learn and do mathematics. Corequisite students, Amanda, Isbelia, and Gloria, all discussed feeling a greater sense of ability and understanding in response to successes in their College Algebra assessments. Verbal persuasion from the instructor was another source that helped students perceive themselves as more capable. Chih-Wei, Adriana, and Isbelia shared how appraisal from Ms. Addison helped them feel more confident and supported in their learning and interaction with the course material.

The students, by and large, appreciated their corequisite course and their corequisite instructor. Many of the corequisite students attributed their positive experiences in the corequisite to Ms. Addison’s personality and the collaborative class climate she fostered within the class. She projected a feeling of caring and understanding that motivated students to engage more with each other and with the course content. The corequisite students discussed how there was a sense of community in their corequisite course whereas there were mixed feelings about the lecture courses among the lecture students. While students in Ms. Addison’s and Ms. Martinez’s lecture believed that there was a sense of community, students in Ms. Rose’s and Ms. Johnson’s class were less convinced.

These diverse classroom experiences contributed to students’ perceptions of mathematics and mathematics learning. Through enrollment in the corequisite, students developed a better mathematical foundation that helped them become more organized and prepared for their lecture course. Corequisite students reported feeling more confident in their mathematical abilities and having a greater interest in doing and learning mathematics because of their experiences in their corequisite course. For instance, Isbelia reported having a negative experience learning mathematics in high school. This bad experience caused her to question whether a career in biology was possible given her anxiety about mathematics. After taking the corequisite Isbelia shared "I don't dread math anymore." She reported feeling more confident going into her next math class (Pre-Calculus).

The direct relationship between the corequisite and the lecture course allowed Ms. Addison to dig deeper into the College Algebra content and provide more opportunities for extended learning and practice within the corequisite. This was especially important for the corequisite students, many of whom reported having prior negative experiences learning mathematics and negative perceptions of their ability to do and understand mathematics. Corequisite courses are positioned to provide this type of academic support since they are not burdened by time limits as much as lecture courses. These support courses can serve as venues for academic and emotional support, identity-development, and community-building through active and collaborative activities. These were the key elements that the corequisite students valued in their learning experience.

Chapter 7: Discussion and Conclusion

Introductory STEM courses at postsecondary institutions simultaneously function as gateways and gatekeepers to higher education for historically minoritized and marginalized students. While these courses provide access to upper-level STEM courses and majors, they also function as academic roadblocks. The weed-out culture that is synonymous with these courses (Weston et al., 2019), as well as the inadequate support for students that enter these courses with underdeveloped prerequisite skills (Koch, 2017), contribute to the systemic problem of STEM attrition. The corequisite model of academic support was introduced at many institutions nationwide to combat this equity issue. The purpose of this multiple-level study was to explore the student experience within a corequisite course linked to an introductory mathematics course (College Algebra) at a public four-year institution. This study took place at multiple levels because it focused on the student experience and engagement within classrooms (microcosms of the larger academic ecosystem), as well as analyzed the broader institutional context in which these courses exist.

Data collection for this study occurred during the global coronavirus pandemic. Due to the pandemic, all classes met virtually, and thus the nature of student engagement shifted from the in-person setting to the virtual. There is not a bijective relationship between the in-person classroom and the virtual classroom. Pedagogical moves for engaging students in course content was especially important during this time since students could have easily disengaged by staying muted during synchronous class meetings, with their videos off while distracted by non-course related activities. Fortunately, the pedagogical moves for ensuring greater and more inclusive student participation in the virtual space are some takeaways from this study that can be brought to and modified for the in-person classroom.

Through classroom observations, conversations with students and institutional stakeholders, and the collection of student artifacts (surveys and course reflections), I was able to better understand the corequisite student experience and how the corequisite course was developed and functioned at Grizzly State University (GSU). Findings from this study will inform institutional leaders on the potential benefits of the corequisite model for student learning and course completion. This study also highlights the institutional design and execution process that has led to GSU's more recent successes. Findings from this study can be used to inform professional development around inclusive instructional practices for engaging students. I begin this final chapter by reiterating the major findings from the study, which I delineate by the three research goals of this study. I then highlight my contributions to the literature. Following, I provide the limitations of this study. Afterward, I present some implications for practice. I conclude this chapter with some future directions for this work.

Summary of Findings

Research Goal 1

The first research goal of the study was to describe an implementation of the corequisite model at a public four-year institution. The following focused research questions were presented towards addressing this goal:

a. What are the goals and beliefs of institutional stakeholders as they pertain to the corequisite model?
b. How are institutional stakeholders working together to ensure the successful implementation of the model?
c. What is the nature of the academic support available to students in corequisite courses?

The College Algebra corequisite model at GSU evolved significantly between the first semester of implementation during the Fall 2018 semester to the time of data collection for this study during the Fall 2020 semester. Each member of the instructional team had their own thoughts and beliefs about the corequisite model. Throughout the five iterations of the College Algebra corequisite support course, the team of instructors and course coordinator coalesced around three core beliefs and goals around the College Algebra lecture and support courses. First, they coalesced around the idea that the course sections needed to be coordinated to ensure that students were learning and being assessed in the same way across sections. Second, the instructional team coalesced around a change in instructional approach to include more active and collaborative learning opportunities. This move was important in supporting student development of the communicative skills needed for subsequent STEM courses at GSU. Third, the instructional team became more aligned around the idea that metacognitive and study skills activities were important and necessary aspects for the corequisite course. Throughout the five semesters they learned that simply providing additional practice of lecture course content in the corequisite course was not enough to support the wide range of student needs, some including executive functioning.

Research Goal 2

The second research goal was to examine how opportunities to engage in course content were distributed within corequisite courses. The following focused research questions were presented towards addressing this goal:

a. How are opportunities to engage in course content distributed in corequisite courses vs. lecture courses?
b. How do students in corequisite courses engage in their lecture courses?

Three lecture course sections and the single corequisite course offered during the Fall 2020 semester were observed during this study. While the lecture course sections enrolled between 33 and 49 students, the corequisite course was a smaller course with only 24 students enrolled. Students in the corequisite course were provided more opportunities to engage in breakout rooms than the lecture students. Hence, the corequisite students spent a proportionally greater share of class time collaborating in small groups in the corequisite than they did in their lecture course. There was a statistically significant relationship between the amount a corequisite student participated in their corequisite course and their final lecture course grade.

The virtual Zoom classroom provided three venues for student engagement: the main room, the breakout rooms, and the chat. The Zoom chat was the most utilized venue across many of the observed classes. In this venue certain groups of students were more represented in the classroom discourse than other students. This participation imbalance was prevalent in all observed courses. For instance, the corequisite women were underrepresented in the Zoom chat, but the opportunity to collaborate in the breakout rooms led to more proportional representation in the classroom discourse. Thus, the secondary venue for student participation provided students with more opportunities to participate at their comfort. The lecture instructor that mainly utilized a single venue, Ms. Johnson, had the least amount of student engagement throughout the observation period than the other instructors.

The quality of the student discourse in both the lecture and corequisite course were at cognitively low levels, where the instructors asked students to provide numerical answers and recall mathematical facts (as opposed to justifying reasoning and describing steps in problem solving). The corequisite students engaged in this manner in both their lecture and corequisite course. The main difference in the corequisite student engagement between their lecture course and corequisite course was that they participated more often in the corequisite course unsolicited (i.e., the instructor did not explicitly call on them to participate) and the instructor responded to a greater share of their contributions in their corequisite course than their lecture course.

Research Goal 3

The final research goal was to understand the impact on the student. To address this goal, I posed the following research question:

a. How are students' interests, beliefs, and attitudes around mathematics and mathematics learning affected through enrollment in the corequisite course?

The classroom environment in the lecture sections and the corequisite were different, and the corequisite students approached them differently. The corequisite students characterized their corequisite course as a venue for tutoring whereas the lecture course was perceived as more serious. One student described instances where she would postpone asking questions from the lecture course until she was in the corequisite course. Through the corequisite course, students had more opportunities to interact directly with their instructor in addition to collaborating with and learning from their peers. These students positioned group work as more beneficial than their non-corequisite peers.

These experiences coupled with the climate the instructor fostered in the corequisite course resulted in students feeling encouraged, supported, and more confident in their mathematical abilities. Several students described feeling a greater sense of ability and understanding because of the preparation they received from their corequisite course. Some students credited their newfound confidence to positive appraisals from the corequisite instructor. Even for the one student who stated that the corequisite course did not change her attitudes towards mathematics and mathematics learning, she explained that the corequisite course pushed her to become more organized in her classes. Consequently, this study provides evidence of the potential for corequisite courses to support student learning and development.

Contribution to Knowledge

The findings from this study illustrate how the various levels (the institution and the classroom) of the academic ecosystem can impact the student experience within the classroom. I approached this study with the assumption that greater student learning in corequisite courses is possible when classroom environments are simultaneously engaging, equitable, and inclusive. I further hypothesized that this type of classroom environment can lead to a greater sense of student academic efficacy. The findings from this study support the idea that open and engaging corequisite classroom environments result in students having a greater perception of learning and understanding, and a greater sense of ability. In this section I provide insights on how course coordination and instructor professional development can be leveraged to enhance the student learning experience.

Course Coordination

The creation of the College Algebra course coordinator position was paramount to GSU's progress in developing the corequisite course. In fact, coordinated courses and having a permanent course coordinator was one of the features of successful Pre-Calculus to Calculus II programs, as identified by Rasmussen et al. (2014, 2019). While College Algebra does not fall within the Pre-Calculus to Calculus II pathway, it is a critical prerequisite course for students pursuing STEM majors that do not place directly into Pre-Calculus or Calculus I. Thus, course coordination in prerequisite courses along the STEM pathway can have a positive effect on course delivery and students’ classroom experiences in prerequisite STEM courses.

The course coordinator was able to assemble a team of educators that were committed to the academic preparation and development of students. The Four Frames for Systemic Change framework highlights how different people within a community have individual perspectives and goals, and for a cultural change to occur, a shared vision must emerge that accounts for these individual goals (Reinholz & Apkarian, 2018). The weekly coordination meetings provided opportunity for this co-construction among team members. Allen et al. (2018) highlighted the need for lecture and corequisite instructors to work in concert. The corequisite instructor at GSU was part of the instructional team, and was actively involved in creating, assessing, and developing the course materials. The coordination meetings with the instructional team also were opportunities for temperature checks on how the corequisite students were doing in the lecture course. Consistent with the conclusions of Allen et al. (2018), "a blind model [is] not in the best interest of students" (p. 37). Or in other words, students receive the best corequisite experience when there is continued communication between relevant instructional stakeholders.

A Need for Professional Development

While research on corequisites demonstrate the potential for this academic support mechanism to reduce "equity gaps," attrition of Black and Latinx students continue to persist in these courses (Mejia et al., 2020). As Dr. Byron P. White (2016) suggested, institutions must move away from the "college-ready" paradigm of measuring whether students are prepared enough to engage with their courses, towards a "student-ready" approach where they create structures to support the diverse needs of their student body. If we care about student success, we must critically examine what is going on within the classroom. Given that corequisite courses are often populated by students from marginalized communities, the findings from this study further highlight the pressing need for institutions to be student-ready. A concrete step towards being student-ready is providing instructors with resources for continued professional learning and development towards creating active and inclusive learning opportunities in corequisite courses.

Introductory math courses are oftentimes taught by part-time, non-tenured, and/or less experienced instructors with less access to professional development resources (Kosiewicz et al., 2016; Supiano, 2018). Institutions must invest in professional development for their instructors, such that they are better positioned to foster rich, equitable, and inclusive classroom environments. The student experience in the Fall 2020 corequisite was greatly influenced by Ms. Addison's instructional practices, and the climate and community she fostered in her classroom. This finding is consistent with Frisby and Martin's (2010) work in highlighting the relationship between students' perceptions of classroom rapport and the extent to which a classroom is supportive. Through many iterations of course redesign (with the course coordinator) and professional development, Ms. Addison was able to create a space in the corequisite course where students felt comfortable learning and academically supported. In a sense, the instructor, their beliefs, and their instructional practices significantly impact the classroom environment they foster. Therefore, supporting student learning and development in corequisite courses necessitates an investment in the professional growth of the instructor.

Limitations

There were two main limitations to this current study. One limitation was the small sample of corequisite students. During the Fall 2020 semester, only 24 students were enrolled in the corequisite course. This small number led to an even smaller sample size (seven) of corequisite respondents to the SPIPS. This small sample size inhibited the execution of statistical analyses with sufficient power in comparing the corequisite students to their non-corequisite peers. Nevertheless, there was an abundance of qualitative data to help illustrate the nature of the corequisite student experience at GSU.

A second limitation of this study was generalizability. As the chair of GSU's mathematics department pointed out, each institution is unique and what works for one institution may not work for another. Hence the portrait of the institutional context in Chapter 4 was especially important for characterizing how change occurred at this public four-year Hispanic Serving Institution. While these characteristics are not universal to every four-year institution, as highlighted in the Contributions to Knowledge section, there are valuable and transferable lessons that can be taken from this study.

Implications for Practice

Consistent with previous research (Kashyap & Mathew, 2017; A. D. Smith, 2019; Wakefield, 2020), I conclude that the adoption of the corequisite model is a step towards addressing the access issues related to student persistence and attrition. GSU's success in the College Algebra corequisite course was contingent upon the multiple levels of the academic institution working in concert. In the classroom, the corequisite instructor had the academic flexibility to design and incorporate activities that would support her student's academic development. Through course coordination the corequisite instructor was certain that her corequisite students were exposed to the same lecture material prior to entering the support course. Nevertheless, there are additional steps that institutional leaders must consider in supporting their students in introductory STEM courses. Despite the stated limitations, the findings from this dissertation suggest several implications. In this section I present implications for institutions and instructors.

Implications for Institutions

One implication for practice suggested by the findings from this study is the need for institutions to develop a closer relationship between their campus student advising office and the discipline departments. For instance, student placement was a persistent problem at GSU where groups of students needed a corequisite support and were not offered it, and other groups of students were inappropriately placed in the corequisite. These kinds of issues can be avoided when there exists robust relationships and partnerships between these various institutional entities. Through partnership, institutional stakeholders can support the whole student (their personal and academic needs).

A second implication for practice is the practice of using local data to inform change. While a rigorous study on the success of the corequisite model had not been conducted at GSU prior to the Fall 2020 semester, there was anecdotal evidence and miniature studies done throughout the five iterations. Anecdotally, the course coordinator and instructors recognized that simply providing extra practice of lecture content was insufficient for the needs of the corequisite students. As a result, the course coordinator conducted a study on the effect of the metacognitive activities in the corequisite course and found that those activities were beneficial for students' metacognitive development and course outcomes. Decreased DFW rates during that semester (and the semesters that followed) supported the move to incorporate metacognitive activities, and therefore these activities persisted in the corequisite course. Thus, the design of a corequisite course should be the result of data-informed decision-making over iterations of course deployments, based on the local context.

Implications for Instructors

Based on the classroom observations and student recollection of their experiences, I identify in Table 7.1 three inclusive instructional practices that allowed for greater student classroom engagement within the observed classrooms. The listed practices are in addition to the recommended practices by the Mathematical Association of America for fostering student engagement in their *Instructional Practices Guide* (2018).

Table 7.1. Observed inclusive instructional practices.

Practice 1	Leverage student voices by encouraging students to engage with each other's ideas.
Practice 2	Delegate mathematical authority by positioning students as capable doers of mathematics.
Practice 3	Provide multiple entry points into the classroom discourse.

The first practice is leveraging student voices by encouraging students to engage with each other's ideas. The corequisite instructor's instructional moves in the breakout rooms for soliciting student participation and greater student-to-student interactions is an example of this practice. In the virtual and in-person classroom, instructors can leverage student voices by encouraging students to respond to each other's ideas before responding or evaluating their contributions. Instructors can establish norms for classroom engagement – in the virtual classroom that may include assigning student roles in the breakout rooms like having one student sharing their screen while others annotate and report back to the whole class.

The second practice is delegating mathematical authority by positioning students as capable doers of mathematics. An instructor can exercise this practice by creating classroom norms that encourage student participation, using a variety of strategies for soliciting participation, and elevating student ideas. This action of elevating student voices and delegating mathematical authority, positions other members (apart from the instructor) as competent individuals in the mathematics community. As described by Dunleavy (2015), this is an example of cultivating an inclusive classroom environment.

The third practice is providing multiple entry points into the classroom discourse. The instructors that were able to engage more students in the classroom discourse were the ones that established multiple venues for student participation. In the virtual classroom, this means opening more venues for student participation, including the public chat, the whole class setting, and the breakout rooms. For the in-person setting, this means utilizing a variety of instructional approaches outside of the lecture style of instruction. These include small group activities, discussion boards, and classroom instructional tools (e.g., clickers). Providing multiple entry points to the classroom discourse lends way to more inclusive classroom environments where students can participate in a manner that suits their personal learning needs.

Future Work

There are two future paths in which I would like to continue this work. First, I wanted to learn about the effects of corequisite courses on historically marginalized and minoritized groups. Due to the small sample size and incomplete demographic student data, I was unable to fully capture differences (if they existed) across racial and ethnic groups. Understanding the experiences of Black and Latinx students is important because these students tend to make up a larger portion of academic support courses at postsecondary institutions. A future study will attend to these pertinent details. In addition, and as illustrated in Chapter 6, the corequisite student is not a monolith. Each student enters the classroom with a variety of lived experiences. A future study will investigate the interplay of student identity and academic support systems for mathematics courses in postsecondary institutions.

A second path for this research is to investigate the extent to which student gains from the corequisite course are lasting. From this study I learned that the College Algebra corequisite course at GSU prepared students for their College Algebra lecture. From the Fall 2018 to the Fall

2019 semester (prior to the coronavirus global pandemic) the pass rate for corequisite students was increasing. This rate also continued during the semesters of virtual instruction during the pandemic. A future study would be longitudinal and would track corequisite students throughout their STEM pathways to examine whether lessons learned (content) and developed skills (metacognitive work) from the corequisite course helped them and were sustained through subsequent STEM courses.

Appendix A: Student Postsecondary Instructional Practices Survey (SPIPS)

Introduction

Welcome! We are working with Grizzly State University to better understand College Algebra courses at your institution. We have asked your instructor to award you course credit for participating in our study.

If your instructor is offering course credit, you must enter your school ID number and email address, and which course section you are enrolled in.

Please complete your survey by December 14, 2020 at 11:59pm.

In appreciation of your time and effort completing the survey, you will be automatically entered into a raffle to win one of five $30 Amazon gift cards.

Please read the project description and informed consent that follows. Thank you in advance for your time, and your contribution to this work.

Student ID:

Please enter your GSU email address.

Which course and section are you enrolled in?

Course name and number

Instructor

Scheduled time

Results of this survey and the information gathered through class observations will be kept completely confidential. Participation is optional, but we hope you will contribute to our study, so that we may better understand your experiences with College Algebra at GSU. In addition to questions about your experience in your current mathematics course, this survey contains a few mathematics questions and questions about your background and prior experience.

For more information about the project and if you have any questions about your participation please contact Amelia Stone-Johnstone at #insert email# or Mary Pilgrim at #insert email#.

Do you consent to participate in this survey?

- Yes
- No

To participate in this survey, you must be 18 years old, or older. Are you?

- Yes
- No

Thank you for participating! Your progress will be automatically saved every time you move to the next page. If you experience any difficulties, please contact Amelia Stone-Johnstone at #insert email# or Mary Pilgrim at #insert email#.

Are you Co-enrolled?

Are you currently co-enrolled in College Algebra Support, MWF 9:00-9:50 with Ms. Addison?

- Yes
- No

Classroom Experience

How helpful are each of the following with your work in College Algebra?

	Extremely helpful	Very helpful	Somewhat helpful	Minimally helpful	Not at all helpful	Not applicable
Private Tutor	○	○	○	○	○	○
Group Activities	○	○	○	○	○	○
Friends and/or Family	○	○	○	○	○	○
MyMathLab	○	○	○	○	○	○
Math Support Center at GSU	○	○	○	○	○	○
Instructor Office Hours	○	○	○	○	○	○

What things (class activities, projects, campus resources, clubs, people) have you found to be particularly **unhelpful** to you as a student in College Algebra?

Roughly how often have you missed class meetings for College Algebra?

	(Almost) never	Occasionally	Frequently	I've missed more than half the classes
Regular class meetings	○	○	○	○

What percent of **regular class time**, over the whole term, did you spend…

	0	25	50	75	100	
Working on problems individually	○					0
Working on problems in small groups	○					0
Participating in (contributing and/or listening to) whole-class discussions	○					0
Listening to the instructor lecture or solve problems	○					0
Total:						**0**

Indicate the degree to which the following statements describe your experience in College Algebra.

	Always	Very often	Sometimes	Rarely	Never
The test questions focus on important facts and definitions from the course	○	○	○	○	○
I make connections between related ideas or concepts when completing assignments	○	○	○	○	○
The test questions require me to apply course concepts to unfamiliar situations	○	○	○	○	○
I receive feedback on my assignments without being assigned a formal grade	○	○	○	○	○

	Always	Very often	Sometimes	Rarely	Never
I attend tutoring sessions or seek help outside of class time	○	○	○	○	○
I work with peers outside of class on math problems	○	○	○	○	○
I see my instructor(s) outside of class for help	○	○	○	○	○

Where do you go for tutoring or extra help?

- ☐ GSU Mathematics Support Center
- ☐ Office hours
- ☐ Friend(s)
- ☐ Private tutor
- ☐ Extra course sessions (e.g., Friday classes on non-quiz days)
- ☐ Other (please explain)
- ☐ I have never asked for extra help or tutoring

Indicate whether you agree or disagree with the following statements about your experience in **regular course meetings** of Math 140.

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
I talk with other students about course topics during class	○	○	○	○	○
I work on problems individually during class time	○	○	○	○	○
I discuss the difficulties I have with math with other students during class	○	○	○	○	○
I share my ideas (or my group's ideas) during whole class discussions	○	○	○	○	○
I receive immediate feedback on my work during class (e.g., student response systems such as Zoom chat and Zoom polls)	○	○	○	○	○
Multiple approaches to solving a problem are discussed in class	○	○	○	○	○

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
The instructor explains concepts in this class in a variety of ways	○	○	○	○	○

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
The instructor knows my name	○	○	○	○	○
I have enough time during class to reflect about the processes I use to solve problems	○	○	○	○	○
I constructively criticize other student's ideas during class	○	○	○	○	○
A wide range of students respond to the instructor's questions in class	○	○	○	○	○
The instructor adjusts teaching based upon what the class understands and does not understand	○	○	○	○	○
	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
My instructor uses strategies to encourage participation from a wide range of students	○	○	○	○	○
The class activities connect course content to my life and future work	○	○	○	○	○
There is a sense of community among the students in my class	○	○	○	○	○
I am asked to respond to questions during class time	○	○	○	○	○
I receive feedback from my instructor on homework, exams, quizzes, etc.	○	○	○	○	○
I listen as the instructor guides me through major topics	○	○	○	○	○
	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
A wide range of students participate in class	○	○	○	○	○
I work with other students in small groups during class	○	○	○	○	○
In my class a variety of means (models, drawings, graphs, symbols, simulations, tables, etc.) are used to represent course topics and/or solve problems	○	○	○	○	○
	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree

For each of the following activities, please indicate how much each helps your learning in Math.

	Very helpful	Somewhat helpful	Not helpful
Working with other students in small groups during class	○	○	○
Receiving immediate feedback on my work during class (e.g., student response systems such as Zoom chat and Zoom polls)	○	○	○
Being called on to respond to questions during class time	○	○	○
Receiving feedback from my instructor on homework, exams, quizzes, etc.	○	○	○
	Very helpful	Somewhat helpful	Not helpful
Working on problems individually during class time	○	○	○
Talking to other students about course topics during class	○	○	○
Having the class structured to encourage peer-to-peer support among students (e.g., ask peer before you ask instructor, having group roles, developing a group solution to share)	○	○	○
My instructor using strategies to encourage participation from a wide range of students	○	○	○
	Very helpful	Somewhat helpful	Not helpful
Listening to the instructor guide me through major topics	○	○	○
Constructively criticizing other student's ideas during class	○	○	○
When the instructor knows my name	○	○	○
Using class activities to connect course content to my life and future work	○	○	○
	Very helpful	Somewhat helpful	Not helpful

To what extent are the following course elements helpful to your learning in College Algebra?

	Very helpful	Somewhat helpful	Not helpful	Not Applicable
Written Homework	○	○	○	○
Group Activities	○	○	○	○
Group Quizzes	○	○	○	○

	Very helpful	Somewhat helpful	Not helpful	Not Applicable
Online Homework	○	○	○	○
Friday Lecture Videos	○	○	○	○
Individual Quizzes	○	○	○	○

Consider your **regular course meetings** of College Algebra. As compared to other students in class…

	A lot less than other students	Somewhat less than other students	The same as other students	Somewhat more than other students	A lot more than other students
How much opportunity do you get to answer questions in class?	○	○	○	○	○
How much attention does the instructor give to your questions?	○	○	○	○	○
How much help do you get from the instructor?	○	○	○	○	○
How much encouragement do you receive from the instructor?	○	○	○	○	○
How much opportunity do you get to contribute to class discussions?	○	○	○	○	○
How much praise does your work receive?	○	○	○	○	○

How would you describe the overall climate within College Algebra?

Excluding and Hostile	○	○	○	○	○	Including and Friendly
Intellectually boring	○	○	○	○	○	Intellectually stimulating
Academically easy	○	○	○	○	○	Academically rigorous

Please indicate your level of agreement for the following statements from the beginning of the course and now.

	Beginning of course	Now
I am interested in mathematics	[▾]	[▾]
I enjoy doing mathematics	[▾]	[▾]
I am confident in my mathematical abilities	[▾]	[▾]
I am able to learn mathematics	[▾]	[▾]
I feel anxious when working with others on mathematics during class	[▾]	[▾]

Please indicate your level of agreement for the following statements from the beginning of the course and now.

	Beginning of course	Now
I can learn from hearing other people's mathematical thinking, even if their thinking is not correct.		
I cannot learn mathematics if the teacher does not explain things well in class.		
When a question is left unanswered in math class, I continue to think about it afterward.		
Nearly everyone is capable of understanding mathematics if they work at it.		
To understand math I discuss it with other students.		
I do not spend more than five minutes on a math problem before giving up or seeking help from someone else.		
Understanding math basically means being able to communicate your reasoning with others.		
In math, it is important for me to make sense out of mathematical approaches before I can use them correctly.		
When a math problem arises that I can't immediately solve, I stick with it until I have made progress toward a solution.		
I enjoy figuring out math problems with other people.		

Demographics

The following demographic questions are intended to help us better understand the variety of student experiences at GSU. For more information about why we ask these questions, click Here.

(Select all that apply) Do you consider yourself to be:

- ☐ Gender fluid or Gender diverse
- ☐ Man
- ☐ Transgender
- ☐ Woman
- ☐ Not listed (please specify):
- ☐ Prefer not to disclose

(Select all that apply) Do you consider yourself to be:

- ☐ Alaskan Native or Native American
- ☐ Native Hawaiian or Pacific Islander

- ☐ Black or African American
- ☐ Central Asian
- ☐ East Asian
- ☐ Hispanic or Latinx
- ☐ Middle Eastern or North African
- ☐ Southeast Asian
- ☐ South Asian
- ☐ White
- ☐ Not listed (please specify): ____
- ☐ Prefer not to disclose

(Select all that apply) Do you consider yourself to be:

- ☐ International student
- ☐ Transnational (lives in one country and works in another)
- ☐ First-generation college student (i.e., neither parent nor guardian completed a Bachelor's degree)
- ☐ Commuter student
- ☐ Transfer student
- ☐ Returning student
- ☐ Student with a disability
- ☐ Student athlete
- ☐ Current or former English language learner (i.e., English was not the primary language spoken in your childhood home)
- ☐ Parent, guardian, or care-giver
- ☐ Military or veteran
- ☐ None of the above
- ☐ Prefer not to disclose

Did you use FAFSA to apply for financial aid?

- ◯ Yes
- ◯ No
- ◯ I don't know
- ◯ Prefer not to disclose

Did you receive a free grant (e.g., Pell Grant)?

- ◯ Yes
- ◯ No
- ◯ I don't know
- ◯ Prefer not to disclose

Approximately how many hours per week over the term did you work at a job?

- 0
- 1-5
- 6-10
- 11-15
- 16-20
- 21-30
- More than 30
- Prefer not to disclose

What is your age, in years?

How many years have you been at GSU?

- 0-1
- 1-2
- 2-3
- 3-4
- More than 4
- Prefer not to disclose

What is your class standing?

- First-Year
- Sophomore
- Junior
- Senior
- Other (please specify)
- Prefer not to disclose

Have you declared, or do you intend to declare, a STEM (science, technology, engineering, or mathematics) major?

- Yes
- No
- Unsure
- Prefer not to disclose

Which major have you declared, or do you intend to declare?

Do you think your previous math courses adequately prepared you for College Algebra?

- Yes
- No (please explain)

What grade do you expect to get in College Algebra this term?

- A, A+, or A-
- B, B+, or B-
- C, C+, or C-
- D
- F
- Other (please clarify)

As of now, what math course (if any) do you plan to enroll in **next**?

- PreCalculus
- Calculus I
- Calculus for Business analysis
- Other (please explain)
- I do not plan to enroll in another math course

Are there any aspects of your identity (or who you are) that have impacted your experience in mathematics atGSU? Please explain.

Is there anything else you would like us to know about you or your experience in mathematics at GSU?

May we contact you in the future, to further understand your experience in mathematics at GSU?

- Yes, here is my contact email:
- No, thank you.

Thank you for completing our survey! If you would like to revisit any of your responses, please use the back button on this page. Submitting this page will finalize your responses and complete your submission. If you have any questions about the project or this survey, please contact Amelia Stone-Johnstone at email address or Mary Pilgrim at email address.

Additional Questions for Corequisite Students

Classroom Experience - CoEnroll

How helpful are each of the following with your work in College Algebra?

	Extremely helpful	Very helpful	Somewhat helpful	Minimally helpful	Not at all helpful	Not applicable
Friends and/or Family	○	○	○	○	○	○
Private Tutor	○	○	○	○	○	○
Math Learning Center at GSU	○	○	○	○	○	○
MyMathLab	○	○	○	○	○	○
College Algebra Support	○	○	○	○	○	○
Instructor Office Hours	○	○	○	○	○	○
Group Activities	○	○	○	○	○	○

What percent of time in **College Algebra Support**, over the whole term, did you spend…

	0	25	50	75	100	
Working on problems individually						0
Working on problems in small groups						0
Participating in (contributing and/or listening to) whole-class discussions						0
Listening to the instructor lecture or solve problems						0
Total:						**0**

Where do you go for tutoring or extra help?

- ☐ GSU Mathematics Support Center
- ☐ Office hours
- ☐ Friend(s)
- ☐ Private tutor
- ☐ Extra course sessions (e.g., Friday classes on non-quiz days)
- ☐ Review sessions
- ☐ College Algebra Support
- ☐ Other (please explain)
- ☐ I have never asked for extra help or tutoring

Indicate whether you are or disagree with the following statements about your experience in **College Algebra Support**.

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
I receive feedback from my instructor on homework, exams, quizzes, etc.	○	○	○	○	○
There is a sense of community among the students in my class	○	○	○	○	○
I have enough time during class to reflect about the processes I use to solve problems	○	○	○	○	○
The class activities connect course content to my life and future work	○	○	○	○	○
My instructor uses strategies to encourage participation from a wide range of students	○	○	○	○	○
A wide range of students respond to the instructor's questions in class	○	○	○	○	○
	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
I share my ideas (or my group's ideas) during whole class discussions	○	○	○	○	○
I listen as the instructor guides me through major topics	○	○	○	○	○

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
The instructor adjusts teaching based upon what the class understands and does not understand	○	○	○	○	○
I receive immediate feedback on my work during class (e.g., student response systems such as Zoom chat and Zoom polls)	○	○	○	○	○
I work with other students in small groups during class	○	○	○	○	○
I talk with other students about course topics during class	○	○	○	○	○

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
The instructor explains concepts in this class in a variety of ways	○	○	○	○	○
The instructor knows my name	○	○	○	○	○
I constructively criticize other student's ideas during class	○	○	○	○	○
In my class a variety of means (models, drawings, graphs, symbols, simulations, tables, etc.) are used to represent course topics and/or solve problems	○	○	○	○	○
A wide range of students participate in class	○	○	○	○	○
I discuss the difficulties I have with math with other students during class	○	○	○	○	○

	Strongly agree	Somewhat agree	Neither agree or disagree	Somewhat disagree	Strongly disagree
I am asked to respond to questions during class time	○	○	○	○	○
I work on problems individually during class time	○	○	○	○	○
Multiple approaches to solving a problem are discussed in class	○	○	○	○	○

To what extent are the following course elements helpful to your learning in College Algebra?

	Very helpful	Somewhat helpful	Not helpful	Not Applicable
Group Quizzes	○	○	○	○
College Algebra Support	○	○	○	○
Written Homework	○	○	○	○
Online Homework	○	○	○	○
Group Activities	○	○	○	○

	Very helpful	Somewhat helpful	Not helpful	Not Applicable
Individual Quizzes	○	○	○	○
Friday Lecture Videos	○	○	○	○

Consider your **College Algebra Support course meetings**. As compared to other students in class…

	A lot less than other students	Somewhat less than other students	The same as other students	Somewhat more than other students	A lot more than other students
How much opportunity do you get to answer questions in class?	○	○	○	○	○
How much attention does the instructor give to your questions?	○	○	○	○	○
How much help do you get from the instructor?	○	○	○	○	○
How much encouragement do you receive from the instructor?	○	○	○	○	○
How much opportunity do you get to contribute to class discussions?	○	○	○	○	○
How much praise does your work receive?	○	○	○	○	○

How would you describe the overall climate within **College Algebra Support**?

Excluding and Hostile	○	○	○	○	○	Including and Friendly
Intellectually boring	○	○	○	○	○	Intellectually stimulating
Academically easy	○	○	○	○	○	Academically rigorous

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Appendix B: Institutional Leader Interview Protocol

Introduction – Thank you for taking the time to do this interview today. My name is Amelia Stone-Johnstone. The purpose of this research is to study the impacts of classroom-based interventions and examine the sustainability of change efforts here at this institution. I have a few questions for you today about your perspective on these courses.

<u>Questions for Non-Instruction Institutional Leaders (e.g., dpt. chair, course coordinators)</u>

1) What is your name and position in the math department?

2) How long have you been at this institution? How long in this position?

3) What are some of the challenges and successes of teaching math well at this institution?

4) What are your general thoughts about the corequisite model?
    a. What is the purpose of corequisite courses?
    b. Does the College Algebra corequisite course achieve that purpose?

5) What motivated the introduction of this model to this institution, as opposed to other models of academic support?
    a. Who ultimately designed the College Algebra corequisite course?
    b. When was the first semester of implementation?

6) What are your general thoughts and impressions about how the corequisite course is functioning?
    a. What has worked well in the corequisite course since its implementation?
    b. Has there been any evidence of the success of the corequisite course? If so, can you talk more about this?
    c. Do you think that the corequisite course prepares students for their subsequent courses? How have corequisite students performed in their subsequent math course (if they have taken one)?
    d. What has NOT been working well?
    e. What impact do you think corequisite courses may have on students' interest in doing mathematics? Explain
    f. What impact do you think corequisite courses may have on students' confidence in their mathematical abilities?

7) How are students placed in the corequisite course?
    a. What types of students are typically placed in the corequisite course?
    b. Is it possible for students to self-place into the corequisite course? If so, how do students generally determine that the corequisite course is a course that they should consider?
    c. What information is available for students to learn about the corequisite course prior to registering for the course?

8) Who typically teaches the corequisite course?
    a. What is expected of the corequisite instructor?
    b. Is there any department-driven curriculum that governs how the corequisite is taught?

9) Equity has been a major focus here, what does equity mean to you with respect to the College Algebra corequisite course?
    a. In what ways was the corequisite course designed to encourage equitable learning experiences?

10) What other institutional stakeholders, besides Dr. Washington (course coordinator), are involved in the running the corequisite course (including placement decisions and student advising)?

Questions for Instructors

11) How long have you taught mathematics?
    a. How long at this institution?

12) When is the last time you taught College Algebra?
    a. Have you ever taught the corequisite course?

13) Tell me about your experience teaching College Algebra course.
    a. What was a typical day like in your class?
        i. *If you have taught both the lecture course and the corequisite course, how are these two courses different? And did you approach them differently?*
        ii. If I visited, what would I see you doing? And what would I see the students doing?
        iii. How was class time broken up (i.e., what percentage of class time is spent lecturing and working through problems, whole-class discussions, working in groups, and working individually)?
        iv. Do you teach this course differently from other courses you teach? Why/why not?
    b. What types of students do you typically get in this class?
    c. How were students placed in this class?
        i. Do you feel like most were placed into the right math class? Why or why not?
        ii. Do you think there is a stigma around this class, and around the types of students that are placed into these courses?
    d. *What is one thing you liked about teaching this corequisite course? Explain*
        i. *Are there other things that you liked about the course?*
    e. If you could have changed the course, what would you have changed? Explain

14) Describe what kind of instructor you are?
    a. If I asked your students to describe you as an instructor, what would they say?
    b. What are your beliefs and goals regarding teaching?
    c. What teaching approach(es) have you adopted that supports these beliefs and goals? Examples?

<u>Questions for the Undergraduate Learning Assistant (ULA)</u>

15) What is your name and major?

16) How long have you been a student at this institution?

17) How long have you taught/been a ULA for a mathematics course? What courses have you assisted?

18) Were you a ULA for both the College Algebra lecture and support courses?

19) Have you taken College Algebra at this institution? When did you take that class?
    a. Were you enrolled in the corequisite course?
    b. Besides being online, how was this experience similar or different to your experience as a student?

20) What was your role as a ULA for the corequisite course?
    a. When signing up to be a ULA, what did you think were the responsibilities?
    b. What was your relationship with the students?
    c. If you had the freedom to do anything as a ULA, what would you do? In other words, are there other ways that you feel like ULAs can help support students in the corequisite course?

21) What types of professional development or general training did you receive before becoming a ULA for this course?

<u>Questions for Instructors and the Undergraduate Learning Assistant</u>

22) Do you think attendance in the corequisite course is necessary for doing well?
    a. Did students regularly attend class?
    b. What, if any, were the repercussions for missing class?

23) How would you describe the climate in the corequisite course?
    a. Would you say the class was inclusive? Explain
    b. Would you characterize the class as rigorous? Explain
    c. Would you describe the class as competitive? Explain

24) Equity has been a major focus recently at your institution, what do you think equity means in your classes?

a. Do you approach teaching differently for certain students or groups of students in your class? If so, what might you do differently?
b. Do you think classroom participation is necessary for learning course content?
    i. In what ways was equity in participation encouraged in your class?
    ii. Did you notice any patterns around who participates in your class?
        1. Did you find that particular groups of students participated more?
    iii. How were students' contributions evaluated?
    iv. How did you engage students who were quiet and/or not participating?

25) What is your general impression about the corequisite model of academic support?
    a. In your opinion, what is the purpose of corequisite courses? Do they achieve that purpose?
    b. Do you believe that corequisite courses adequately prepare students for success in their next math course?
    c. What impact do you think corequisite courses have on students' interest in doing mathematics? Explain
    d. What impact do you think corequisite courses have on students' confidence in their mathematical abilities?

26) What, in your opinion, is the most important issue related to corequisite courses that I should know?

27) Demographics
    a. How do you identify yourself, in terms of the following:
        i. gender,
        ii. race/ethnicity, and
        iii. Transborder instructor?
    b. What language(s) do you speak? What is your primary language?
    c. Were you a first-generation college student?
    d. What is your instructional status at this institution (i.e., are you full-time vs. part-time/adjunct, tenure-track vs. non-tenure track)?
    e. Are there any aspects of your identity that have impacted your experience and/or approach to teaching this class?

<u>Question for all interviewees</u>

28) Is there any additional information you would like to add?

Appendix C: Corequisite Student Interview Protocol

Thank you for taking the time to do this interview today. My name is Amelia Stone-Johnstone. I am interested in how different instructional models impact students' experiences in mathematics. One instructional model is the corequisite model where, as you are aware, students are enrolled in both a lecture course and a support course. In this interview I would like you to reflect upon your experiences taking the support course and the impact that course has had on you so far. Nothing that you share here will be shared with your instructor, so feel free to be as open as you feel comfortable.

1) What is your name and major?

2) Can you tell me about your experiences learning math over the years?
    a) What is your most memorable experience learning math?
        i) (probes: What happened? When did it happen, who was involved, why was it memorable to you? How has it impacted you since?
        ii) [IF THEY DO NOT BRING IT UP ASK] Do you think of yourself as a math person? Why or why not?

3) How did you end up in the support course?
    a) What is the last math course you were enrolled in prior to College Algebra?
    b) Did you receive a placement for math?
    c) How well did you understand your placement?
    d) Do you feel like you were appropriately placed into support course? Why or why not?
    e) Do you think the other students in your class were appropriately placed into the support course?

4) Tell me about your experience in the support course.
    a) Did you have the same instructor for lecture and the support course?
        i) If not, how was that? Do you see any benefits or drawbacks from having different instructors?
    b) What was a typical day like in the support course? How was it similar or different to the lecture course?
    c) Please describe a moment in this class that stands out as an especially positive experience in this class.
        i) (probes: What happened? When did it happen? What were you thinking and feeling during this moment? Why was this a positive experience for you?)
    d) Thinking back to your time in the class so far, please identify a moment that stands out as a low point.

i) (probe if they do not provide details - What happened? When did it happen? What were you thinking and feeling during this moment? Why does this moment stick out to you as a low point?)

e) What is one thing you liked about the support course? Explain

i) Are there other things that you liked about the course?

f) If you could have changed the support course, what would you have changed? Explain

5) Do you think attendance in the support course is necessary for doing well in the lecture course?

a) How often have you missed class?

b) What about your classmates? Do students regularly attend the support course?

c) What, if any, were the repercussions for missing the support course?

d) Do you attend the Friday classes?

6) How would you describe the climate in the support course?

a) To what extent did you work collaboratively with your peers on coursework?

b) Would you say the class was inclusive? Explain

c) How much encouragement did you receive from your instructor? Peers?

d) Do you attend office hours? Whose office hours?

7) Do you feel comfortable asking or answering questions in the support course? (chat or whole class) Explain.

a) How did you participate in the support course class?

b) How often did you participate by asking or answering questions?

c) Was this different from how you participated in the College Algebra lecture course? If yes, how so?

8) What do you feel like you've gained from the support course so far?

a) What do you hope to get out of the support course by the end of the semester?

b) What are your plans after this semester, as it pertains to mathematics?

c) Do you believe that the support course adequately prepares you for the lecture course?

d) Do you feel that the support course affects how you participate in the lecture course?

e) What affect has this course had on your interest in doing mathematics? Explain

f) What affect has this course had on your confidence in your mathematical abilities?

9) What, in your opinion, is the most important issue related to support courses that I should know?
    a) If you were to describe this course to an incoming student, how would you describe it?
    b) Would you recommend it?

10) Demographics
    a) How do you identify yourself, in terms of:
        i) [veteran or military]
        ii) gender,
        iii) race/ethnicity, and
        iv) Transborder student?
    b) What language(s) do you speak? What is your primary language?
    c) Are you a first-generation college student?
    d) Are there any aspects of your identity that have impacted your experience in mathematics? Or, in this course?

11) Is there any additional information you would like to add to what you have provided?

Appendix D: Lecture Student Focus Group

Thank you for taking the time to do this interview today. My name is Amelia Stone-Johnstone. I am interested in how different instructional models impact students' experiences in mathematics.

This is a focus group interview. Our purpose is to have a conversation. Sometimes what one person says will resonate with your experience. Or maybe you will hear something you disagree with. That is fine. We ask that everyone is respectful. Also, please respect the privacy of your peers. If you have any questions or if you feel uncomfortable at any time, you can ask your question, or ask us to take a break. Do you have any questions for me? [Pause] OK, let's get started.

1) First, introduce yourself. Tell us your name, your major, and something interesting you'd like to share about yourself.

2) When did you start at [insert institution]?

3) Tell me about your College Algebra course. Who is your instructor?
    a) How were you placed in your class?
    b) How well did you understand your placement?
    c) How did you decide which math class to enroll in?
        i) School counselor, orientation, friend?
    d) Do you feel like you were placed into the right math class? Why or why not?
    e) Do you think the other students in your class were placed into the right math class?

4) Are you enrolled in corequisite course (9am with Ms. Addison)?
    a) Did you know that this course was available?
    b) Do you think that you could have benefitted from having a 1-unit corequisite support course?

5) What is the last math course you were enrolled in prior to this class?

6) Tell me about your experience in your College Algebra course.
    a) What was a typical day like?
    b) Please describe a moment in this class that stands out as an especially positive experience in this class.
        i) (probes: What happened? When did it happen? What were you thinking and feeling during this moment? Why was this a positive experience for you?)

c) Thinking back to your time in the class so far, please identify a moment that stands out as a low point.
    i) (probe if they do not provide details - What happened? When did it happen? What were you thinking and feeling during this moment? Why does this moment stick out to you as a low point?)
d) What are your thoughts about group work and group activities?

7) Sometimes class can be dominated by one or two students, and in other classes many students join in.
    a) How do you participate in your math class?
    b) Do you feel comfortable asking or answering questions in your math class? Why or why not?

8) Do you think attendance is necessary for doing well in the course?
    a) How often have you missed class?
    b) What about your classmates? Do students regularly attend?
    c) What, if any, were the repercussions for missing class?

9) How would you describe the climate in the course?
    a) To what extent did you work collaboratively with your peers on coursework?
    b) Would you say the class was inclusive? Explain
    c) How much encouragement did you receive from your instructor? Peers?
    d) Do you attend office hours? Whose office hours?

10) What, in your opinion, is the most important thing I should know about this course?

11) Demographics –
    a) How do you identify yourself, in terms of:
        i) gender,
        ii) race/ethnicity, and
        iii) Transborder student?
    b) What language(s) do you speak? What is your primary language?
    c) Are you a first-generation college student?
    d) Are there any aspects of your identity that have impacted your experience in mathematics? Or, in this course?

Appendix E: Corequisite Student Journal Reflection Form

* Required

1. Email address *

2. First Name *

3. Last Name *

4. Student ID *

5. What grade do you think you will get in this class based on your work in the class so far? *

   Mark only one oval.

   - A
   - B
   - C
   - D
   - F

6. What is the lowest grade you could receive and still be happy? *

   Mark only one oval.

   - A
   - B
   - C
   - D
   - F

7. Approximately how much time, total, have you spent working on College Algebra, this week? (Give your answer in hours) *

8. How much time do you spend doing the following activities each week? (The total time should be approximately equal to your answer above.) *

Check all that

				More
Online homework (MML)	☐	☐	☐	☐
Reading or rewriting class notes	☐	☐	☐	☐
Practicing example from class notes	☐	☐	☐	☐
Practicing problems from the textbook	☐	☐	☐	☐
Practicing problems from homework	☐	☐	☐	☐
Reading the textbook	☐	☐	☐	☐
Getting assistance from the MSLC's virtual tutoring	☐	☐	☐	☐
Meeting (virtually) with a study partner or	☐	☐	☐	☐
Watching videos (e.g., Khan academy)	☐	☐	☐	☐
Getting assistance in virtual office hours	☐	☐	☐	☐

9. Do you have quiet space in which you work on College Algebra? *

Mark only one oval.

- Yes
- No
- Other: ____________

10. At what time of day have you been working on College Algebra outside of class, primarily? *

Check all that

- ☐ Morning
- ☐ Afternoon
- ☐ Evening
- ☐ Late at night
- ☐ Wee hours of the morning

Other: ☐ ______________________________

11. What has been most effective so far in our course? *

12. What has not been effective so far in our course? *

REVIEW YOUR QUIZ:

Review your most recent quiz(zes), or a quiz that you have feedback on.

13. What do you do after a weekly or group quiz?

Do you review the questions you miss? If so, how do you do this?

14. Are you satisfied with your grade on the quiz? Please explain.

15. Does there seem to be a main reason for missing the questions you missed? Were there common errors that you made? (Select all that apply)

Check all that apply.

I had forgotten a formula that I needed.

I could not remember the steps needed.

- [ ] I did not understand what the problem was asking me to do. (i.e., I did not understand the directions)
- [ ] I was not familiar with the vocabulary terms being used in the problem.
- [ ] I was not familiar with the mathematical notation being used in the problem.
- [ ] I did not read the question correctly.
- [ ] I made a mistake in my arithmetic.
- [ ] I made a mistake in my algebra.
- [ ] I made a copy error.
- [ ] I did not completely answer the question.
- [ ] I did not know how to check my answer.
- [ ] I misread the answer choices provided in the multiple choice.
- [ ] I ran out of time.
- [ ] Other.

16. What will you incorporate into your studying to minimize or prevent yourself from making the same mistakes on future quizzes? *

17. Tell me something I should know. *

Appendix F: Field Notes Sheet

Date:
Class Observed: Observer:
Start Time: End Time:

Media File Name:
Transcript File Name:
Chat File Name:

1. Provide a brief description of the lesson covered.

2. Describe what happened during the virtual class. (Ex. Lecture? Breakout Rooms?)

3. How many students were in attendance? (Look at the Participants list, do not include yourself, the instructor, and learning assistants)

4. How many students had their videos on?

5. Estimate the number of students that participated (ex. Handful, half the class, everyone)

6. Anything else that struck you as salient, interesting, illuminating, or important in this contact?

7. Was there a potentially marginalizing moment? If so, explain what happened and how the instructor addressed the situation.

8. What new (or remaining) target questions would you like to consider in your next contact at this site?

9. Minute by minute notes (include who spoke):

Time	Description

10. Screenshot of pictured participants

Appendix G: Themes from Student Interviews

Theme	Description of the Theme	Codes	Evidence
Placement	Discussion about placement procedures and/or how students were recommended to the course that they are enrolled in.	Student selects a lower placement	Student expresses a desire to get a better foundation/re-learn the basics though their placement indicated a higher course. Student did not feel like they would do well in their higher placement. Ex. “so like the school kept emailing me telling me to take Pre-Calculus. And I was like, no, like, you don't understand, like, I suck at math. I don't know anything. So that's why I took from college algebra, because I knew that I wasn't up to par with where they wanted me to start and I'm really glad I did one because taking this class and having an A.”
		Appropriate placement	Student expresses that College Algebra and/or the support course were appropriate starting points for them and/or their peers. Ex. “I took the placement, I guess it was a placement test in order to get out of it and go straight into Pre Calc. I took it and I didn't do well. Like I said, because it had been 10 years since I've taken math .... Well, I'm not going to study and retake it and try and score better and get thrown into Pre Calc because then I would possibly be missing out on some of the basic formulas and stuff.”
		Confusion about placement	Student expresses confusion/frustration about their placement into the corequisite including a feeling that they did not need the course, stating a lack of understanding of the purpose of the course, stating a lack of advisement about the corequisite course. Student comments … Ex. “I thought I fulfilled my requirements, but I guess I didn't so

			yeah it was kind of like … I don't know.”
Virtual Engagement	Discussion about classroom structures that contributed to their engagement. This includes working in groups, nature of their classroom participation, and sentiments around the class climate that would have affected the way they engaged in the classroom.	Groupwork	Student shares a positive or negative anecdote and/or discusses whether collaborative learning was beneficial in the lecture or support course. Ex. “Umm so there was one instance where I was in a breakout room, and it was like nobody did anything but me. So, it was like I did all the work. And I was like, trying to get other people involved, like, Hey, do you guys know what to do here. And like one of the purple persons, like, No, I don't. And then it is just like the other two, they just didn't do anything.”
		Class climate	Student discusses the pace of the course (whether positively or negatively) and the effect on their learning. Student discusses the classroom climate, and/or feeling included. Ex. “she would be going all over the notes and all over the questions like she would go over really fast.” Ex. “I really liked how … everyone was so like they understood like that not every one of us had ... the best with math and you know, like everyone learns differently”
		Class participation	Student discusses the nature of their own engagement, instructor moves that encouraged student engagement, and/or the classroom structures that encouraged them to participate. Ex. “Besides, like being like kind of called on to answer a question I don't really think I did participate, much like I was kind of just like doing my own thing like taking notes and stuff”
Student Affect	Discussion about the corequisite experience (course and/or instructor)	More interested/enjoyment	Student shares that they are more interested in mathematics because of the corequisite course.

	and its influence on student interest, values, confidence, enjoyment, and understanding of course material.		Student shares that they enjoy doing and/or learning mathematics because of the corequisite course. Ex. “I feel like doing more math problem like solving more stuff it's like it gets you addicted or something like that.”
		More confident	Student shares that they are more confident in mathematics because of the corequisite course. Ex. “It's getting me to be more confident as I was having a hard time before. But I am more willing to talk more and explain [how] I got my answers.”
		Greater understanding	Student reports greater efficacy beliefs. Student shares that they have a better understanding of mathematical concepts because of the corequisite course. Ex. “But taking this class is actually really helped me like I feel like I'm finally understanding this.”
		No effect	Student explicitly states that the corequisite course did not influence their affective states (interest, attitude, confidence, enjoyment). Ex. “Honestly, it didn't really affect like my interest in math at all, it kind of just remain the same”

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