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# Learning Mindsets Matter for Students in Corequisite Courses

## Full Report

**AUTHORS**

Yoi Tibbetts, Jamie DeCoster, Michelle K. Francis, Christopher L. Williams, Delaram A. Totonchi, Garam A. Lee and Chris Hulleman

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## Introduction

The current project investigates how *learning mindsets* – students' beliefs and perceptions about learning – impact academic outcomes, particularly among students enrolled in corequisite courses. Because traditional prerequisite approaches to developmental education have been expensive, costing approximately $7 billion[1] with less than promising results,[2] [3] [4] [5] many systems of higher education are shifting toward corequisite developmental education models.[6] To better support students within these corequisite models, it is important to understand how this approach impacts student motivation and how learning mindsets can be leveraged to enhance this initiative. Historically, strategies that target learning mindsets have been particularly effective for students from traditionally underserved backgrounds[7] [8] (e.g., Black, Latinx, Indigenous, first-generation) who are disproportionately more likely to enroll in corequisite courses.[9] [10] Thus, the current study sought to identify which learning mindsets may be particularly supportive of students enrolled in corequisite courses in order to generate recommendations for better serving these students in the future. Supporting these students through these critical courses increases their likelihood of degree attainment that, in turn, can significantly impact their upward mobility.[11]

## Background on Developmental Education Models

Even though approximately one-third of all college students (and two-thirds of all community college students) enroll in at least one "remedial" course,[12] [13] [14] traditional prerequisite approaches to developmental education remain costly and ineffective. For example, standard prerequisite developmental education, which requires students to take introductory non-credit bearing courses before enrolling in credit-bearing college-level courses (e.g., gateway courses), costs taxpayers over $3 billion each year in direct costs alone, with an additional $2 billion lost in lifetime wages due to students' delayed entry into the workforce.[13] More recent estimates indicate that the annual cost of providing these prerequisite courses nationwide has grown to approximately $7 billion.[1] Despite these costs, studies have found that only 20% of students assigned to traditional prerequisite math courses complete a gateway math course within three years of entering school.[9] A review by Jaggars et al. (2014) suggests that this failure of traditional remediation is largely because a significant proportion of remediated students exit the higher education pipeline before they take a critical gateway course.

This leaky pipeline is the result of structural barriers that impede the progress of students who many schools used to deem as "academically underprepared." For example, research indicates that being placed in "remedial" courses may convey messages to students that they are not "college material"[15] and could result in the discouragement and stigmatization that many students enrolled in corequisite courses experience.[4] Indeed, it seems as though the developmental education landscape would benefit from a more motivationally supportive framing of their initiative(s). Additionally, in traditional "prerequisite remedial" programs, students enroll in courses for no credit.[2] Being forced to take college courses for no credit creates an additional structural barrier for students related to the affordability of higher education. In past[16] and present research, students from historically lower socioeconomic backgrounds are more likely than students from higher socioeconomic backgrounds to be placed into corequisite courses compared to traditional gateway courses. For example, first-generation status (i.e., whether or not a student's parent/guardian holds a four-year degree) and Pell grant status (i.e., whether or not a student receives a need-based federal grant) are often used in research as a proxy for socioeconomic status (with first-generation students and Pell grant recipients representing students from lower socioeconomic backgrounds). First-generation students and Pell grant recipients are more likely to be enrolled in developmental math courses[16] that historically have not granted college credit, thereby forcing these students to spend even more of their limited time and money on obtaining a degree. When considering that community college students (compared to four-year college students), and first-generation students in particular, are already more likely to have families to financially support and/or work full time,[17 18] the cost and time required to enroll in additional credit-bearing courses after completing remedial courses creates an additional barrier for these students. Clearly, prerequisite models of remediation have been failing our students.

Given the inefficiency of traditional prerequisite approaches, systems of higher education have begun implementing new models designed to enroll students that colleges label as "academically underprepared" in college-level courses sooner.[6] This approach, often called "corequisite remediation," places students who would historically be placed in prerequisite courses directly into college-level courses with additional learning supports. Recent research into the novel corequisite remediation model has demonstrated promising results. The Tennessee Board of Regents (TBR: the system of higher education overseeing Tennessee's 13 community colleges) was one of the first higher-education systems to implement corequisite education at scale by launching corequisite education as a statewide initiative in 2015.[6]

Using a regression discontinuity analysis, researchers investigated the efficacy of TBR's corequisite model and found that, among students with similar academic preparation, those educated within a corequisite model were more likely to pass their gateway math and English courses when compared to similar students enrolled in traditional prerequisite models.[6 19]

Beyond this correlational evidence, results from randomized controlled trials (RCT) also support the effectiveness of corequisite approaches. In a study that examined how assigning students to either a corequisite or prerequisite model affected student outcomes, researchers found that students enrolled in corequisite courses were significantly more likely to pass the associated gateway course when compared to students enrolled in a traditional prerequisite sequence.[20] Other rigorous studies have also found positive effects of a corequisite model on gateway course outcomes and enrollment persistence.[21 22 23 24 20]

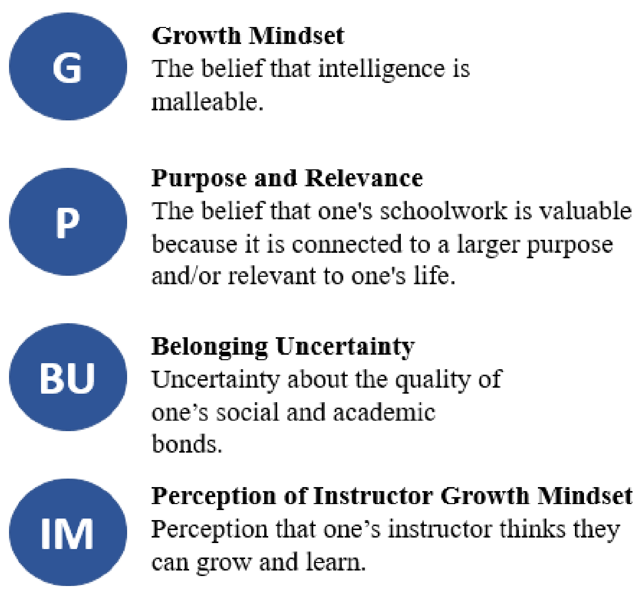
Despite these promising findings, further research is required to better understand how to maximize the effectiveness of this approach.[25] For example, prior research has noted that often the positive effects of corequisite enrollment on student outcomes decrease over time,[20] and researchers have suggested additional studies should examine why students enrolled in corequisite courses do not uniformly perform as well as their peers who are not enrolled in corequisite courses.[25] Because developmental education models have historically used stigmatizing practices that can lead to students feeling like they are not "college material," we believe it is important to understand how educators can cultivate more motivationally supportive learning climates that allow students to thrive. To do so, it is important to examine student motivation within the context of corequisite models.

## Background on Motivation and Learning Mindsets

Given the growing evidence for and popularity of corequisite models,[26] it is necessary to examine how the motivation of students enrolled in these corequisite courses can be leveraged to further support their development. Understanding how the learning environment (e.g., the context of corequisite courses) supports or hinders students' adaptive motivation can help educators optimally engage and instruct their students to promote student development and success,[27] thereby enhancing the positive effects of current models of corequisite education.

Learning mindsets – individuals' beliefs and perceptions about learning – are important determinants of motivation. This research has demonstrated how learning mindsets can significantly impact student outcomes, particularly for students who have been traditionally marginalized by higher education systems.[7] [28] [8] Given that a large proportion of students from traditionally underrepresented backgrounds (e.g., Black, Latinx, Indigenous, first-generation) enroll in corequisite courses,[9] [10] examining how learning mindsets operate within these new models of education also holds great promise for supporting educational equity. If a goal of the United States education system is to promote the academic success and social mobility of Black, Latinx, Indigenous and first-generation students, it is imperative that educators and policymakers structure the courses they are likely to enroll in with more motivationally supportive practices. Therefore, leveraging the power of learning mindsets, which have a proven track record of supporting Black, Latinx, Indigenous and first-generation students[7] in classes that serve a large proportion of these students (e.g., corequisite courses), should be prioritized. In order to investigate the role learning mindsets play in corequisite education, the current project focused on four specific learning mindsets that prior research has shown to impact student success (e.g., grades, retention), particularly for students from historically marginalized backgrounds (e.g., Black, Latinx, Indigenous, first-generation college students). Past research indicates that all four of these learning mindsets are influenced by students' learning environments (see Figure 1).

**Figure 1:** *Four Core Learning Mindsets.*



**Growth mindset.**[29] Students with a growth mindset believe that intelligence and intellectual ability are malleable and can be developed.[30] [31] Research suggests that these students, compared to students with a fixed mindset (those who believe intellectual abilities are fixed and unchangeable) are more likely to persist in the face of difficulties and failure.[32] This is, in part, because students with a growth mindset attribute failure to low effort and usage of maladaptive strategies,[33] behaviors that the students have control over and are able to improve. Multiple large-scale studies have found positive relations between growth mindset and students' achievement.[34] [35] Additionally, interventions designed to improve students' growth mindset have found positive effects on students' first-semester GPA[36] and full-time enrollment[37] among students from marginalized groups (e.g., Black, Latinx students). Importantly, these interventions seem most effective when implemented in contexts that permit and encourage students to view their intelligence as malleable.[38]

**Purpose and relevance.**[39] Student perceptions of purpose and relevance refer to their belief that schoolwork is valuable because it is connected to a larger purpose and/or relevant to their life. Research indicates that students who find more purpose and relevance for their course content achieve higher grades,[40] are more likely to persist in their fields,[41] and have higher career aspirations.[42] To increase students' purpose and relevance, some motivational interventions have highlighted the connection between students' course content and their personal and occupational lives.[43] This research has suggested that helping students find personal relevance in the course content increases their interest in their courses and, in turn, improves their performance in the course. In authentic learning environments, it is important that curriculum and instruction are designed and delivered such that students develop adaptive perceptions of purpose and relevance in their courses.

**Belonging uncertainty.**[44] Belonging is the belief that one is academically and socially connected, supported and respected. Student belonging carries important implications for students' academic achievement and persistence.[45] [44] Research also demonstrates that feeling academically and socially integrated and perceiving institutional support are key determinants of students' retention in their academic fields.[46] [47] On the other hand, feeling uncertain about one's social ties and questioning one's fit in an educational environment (i.e., feeling belonging uncertainty) has adverse effects on students' academic outcomes.[44] This uncertainty that is more frequently experienced by students from historically marginalized and underserved backgrounds (e.g., Black, Latinx, Native, first-generation college students), negatively impacts students' identification with their academic domain, grades, persistence and career aspirations.[48] [49] These findings highlight the importance of cultivating learning environments that foster students' sense of belonging, particularly for students from marginalized groups.

**Perceptions of instructor growth mindset.**[50] In addition to studying learning mindsets of students, researchers have recently focused on the role of instructor mindsets and how students perceive the growth mindset of their instructors.[51] [52] Perceptions of instructor growth mindset refers to student beliefs about whether or not they think their instructor has a growth mindset about students. Students who perceive their instructor to have high levels of growth mindset, believe their instructor has confidence that students' intelligence is malleable and they can grow and develop. This shift toward a more critical consideration of how aspects of the learning environment (i.e., instructor mindsets and the extent to which students perceive their instructors to believe in students' abilities to learn and develop) affects student motivation has led to promising new strategies for supporting students from traditionally marginalized backgrounds. For example, Canning et al. (2019) recently found that among a university-wide sample of 150 STEM professors and more than 15,000 students, faculty's mindset beliefs predicted student achievement and motivation. This study also revealed that faculty who espoused more fixed-mindset beliefs (the belief that intelligence is not malleable and cannot be improved) had significantly larger racial equity gaps in their course grades. Specifically, the difference in course grades when comparing White and Asian students to Black, Latinx and Native American students was twice as large in courses taught by faculty who endorsed more of a fixed (instead of growth) mindset about students' intelligence. Additionally, Muenks et al. (2020) found that when students perceive their instructors to have more of a fixed mindset about learning, they are less motivated, experience increased psychological vulnerability, and perform worse academically. These effects may be even more pronounced among students historically marginalized in STEM disciplines (e.g., women in STEM).[52] Given the emerging research on the importance of how students perceive the growth mindset of their faculty, we included it as a critical predictor of student achievement in the current study.

Examining the effects of growth mindset, purpose and relevance, sense of belonging, and perception of instructor growth mindset within a corequisite sample allows us to better understand which kinds of learning mindsets are most salient for students enrolled in corequisite courses. This can then help us develop insight into how we can better support student growth, development and success.

## Context and Descriptive Data

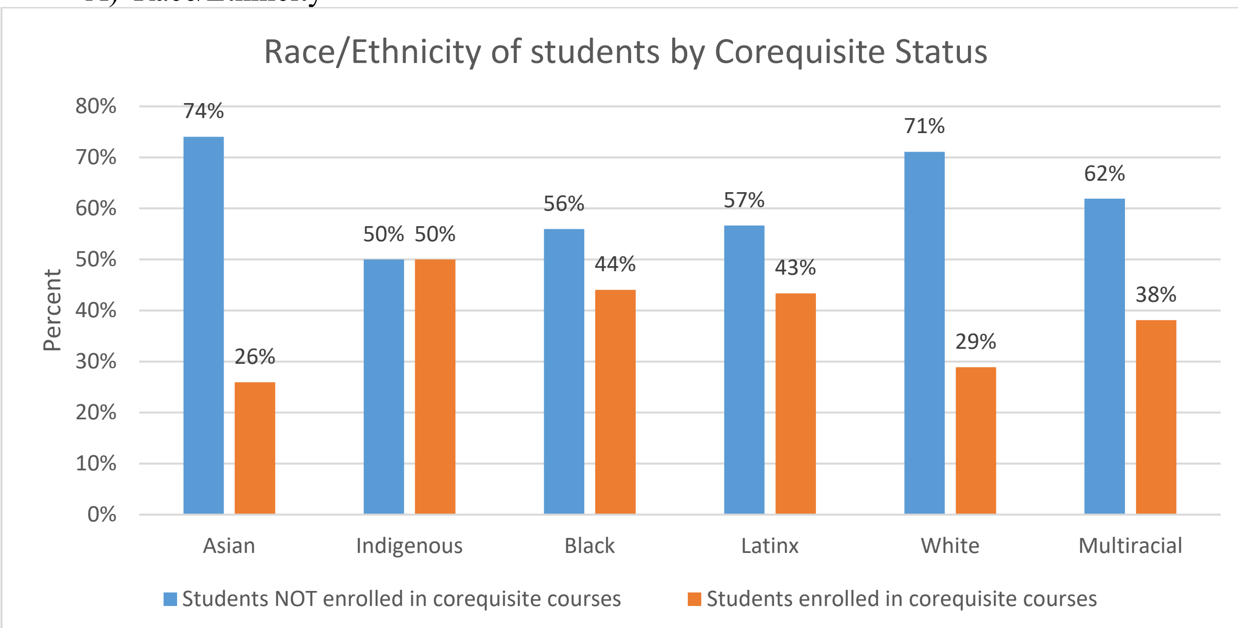
Motivate Lab currently works with the University System of Georgia and the Tennessee Board of Regents investigating the influence of student and faculty mindsets on academic outcomes. The main aim of the current report is to examine the relationship between student achievement and students' learning mindsets, particularly among students enrolled in corequisite courses.

In our study, we assessed the mindsets and academic performance of 7,470 students in Georgia and 2,143 students in Tennessee during their first college semester. Of these students, 35.5% of the students were taking at least one corequisite course (i.e., a learning support course paired with another credit-bearing course) in their class schedule. The sample for the current analyses was derived from a larger study examining the relations of student motivation with academic performance among students entering Georgia state colleges and state universities, as well as Tennessee's 13 community colleges, in the fall of 2018. We focused on these types of institutions because they provided the opportunity for students to take corequisite courses; and we hypothesized that, due to the stigmatizing nature of prior developmental education models, learning mindsets (e.g., belonging) could play a particularly pivotal role in the learning experience of students enrolled in corequisite courses.

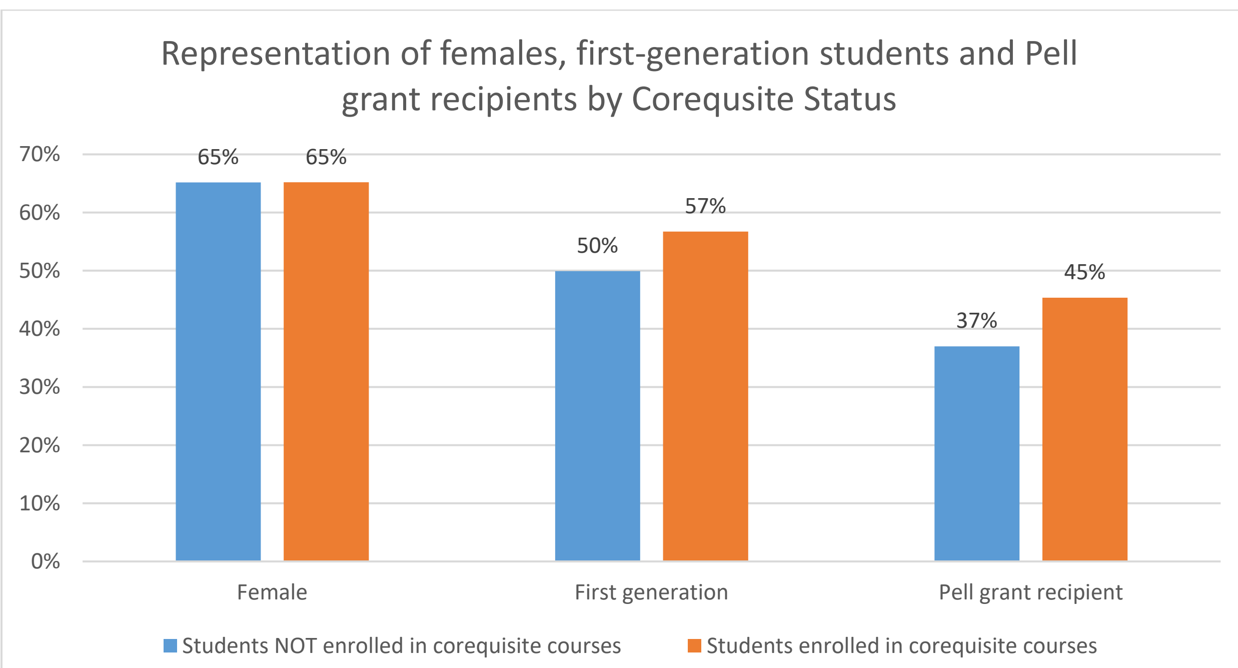
Before understanding the potential impact of taking corequisite courses on academic performance, it is important to understand how students enrolled in corequisite courses differ from students who are not enrolled in corequisite courses. The demographic characteristics of students enrolled in corequisite and non-corequisite courses are presented in Figure 2.

**Figure 2.** *Demographic characteristics of students enrolled in corequisite courses versus students not enrolled in corequisite courses.*

A) Race/Ethnicity




B) Gender, Generational Status, Pell grant Status



These graphs show that although the gender distributions of students enrolled in corequisite and non-corequisite courses are approximately the same, a significantly higher percentage of Black, Latinx, Indigenous and first-generation college students enroll in at least one corequisite course when compared to their White, Asian and continuing-generation student peers. Similarly, a higher percentage of Pell grant recipients enrolled in at least one corequisite course compared to students who did not receive a Pell grant.

We also examined the extent to which students enrolled in corequisite courses differed from their peers in terms of their incoming learning mindsets (i.e., their incoming growth mindset, purpose and relevance, belonging uncertainty and perception of instructor growth mindset).

**Figure 3.** *Incoming academic mindsets of students enrolled in corequisite courses versus students not enrolled in corequisite courses.*

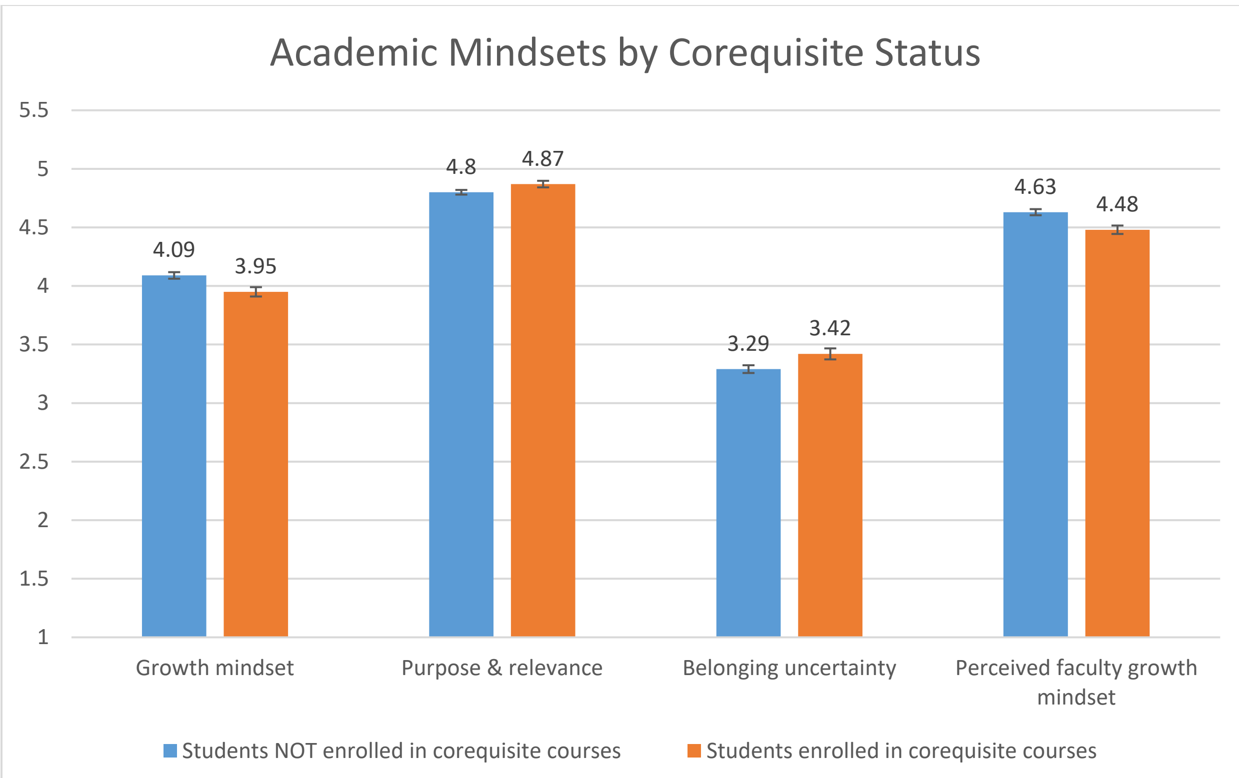


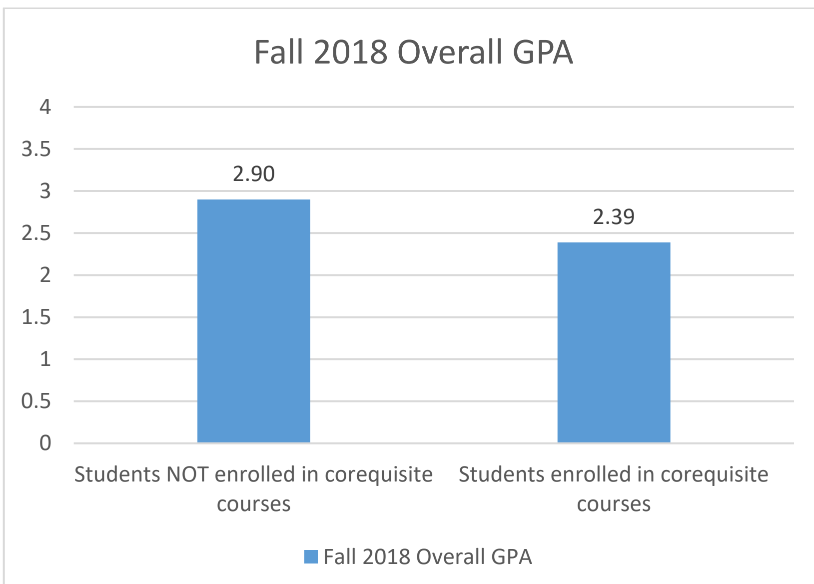

Figure 3 depicts that students who are not enrolled in corequisite courses are more likely to have a growth mindset, feel less belonging uncertainty, and are more likely to initially perceive their instructors as having growth mindsets. Interestingly, students enrolled in corequisite courses tend to have slightly higher (although not significantly) perceptions of purpose and relevance.

**Outcomes of interest**

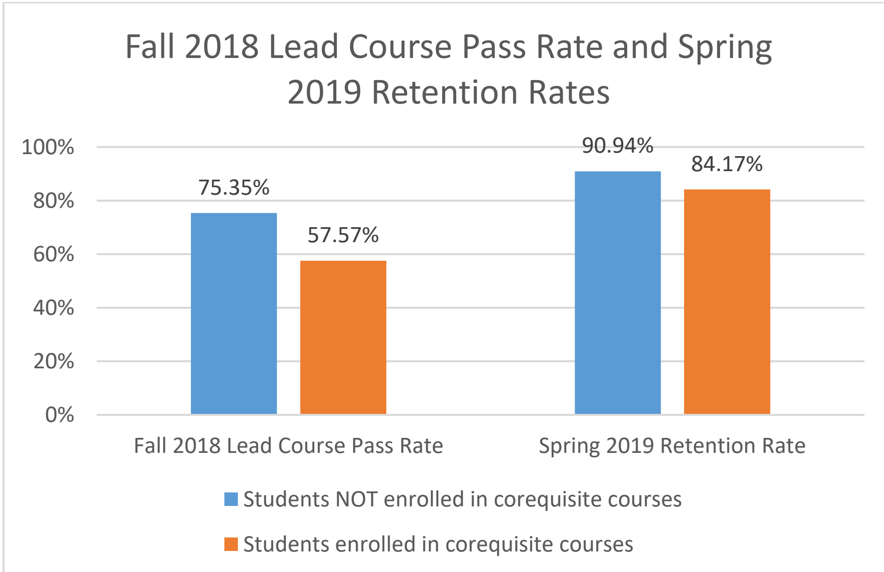
The current report focuses on three different academic outcomes that are critical to the development of first-year students: Overall grade point average (Fall 2018 overall GPA) collected at the end of the Fall 2018 semester; whether students passed their credit-bearing or “lead” course (i.e., lead course pass rates) associated with the corequisite classes in the Fall 2018 semester; and whether students returned to take classes during the following Spring 2019 semester (i.e., Spring 2019 retention). Table 1 provides descriptive information about these outcomes in our sample. Figure 4 illustrates how students enrolled in corequisite courses differ from students not enrolled in corequisite courses across these outcomes.

**Figure 4.** *Outcomes of interest for students enrolled in corequisite courses versus students not enrolled in corequisite courses.*

A) Overall Fall 2018 GPA



B) Lead course pass rates (i.e., the percentage of students who passed the credit-bearing course of the corequisite model) and Spring 2019 retention rate




Taken together, the graphs show that corequisite courses have room for growth in terms of their ability to support students to achieve higher grades, pass their lead courses and enroll the subsequent semester. Importantly, the differences between students enrolled in corequisite courses and students not enrolled in corequisite courses **cannot** be explained by the fact that proportionally more students from racially minoritized backgrounds and first-generation students enroll in corequisite courses. The effects of corequisite status (i.e., whether or not a student is enrolled in corequisite courses) on student outcomes persist even when controlling for students' race, ethnicity, gender, generational status and students' high school GPA. This suggests that some other factor (i.e., a factor unrelated to student demographics and prior academic performance) is accounting for the differences in these critical academic outcomes. For example, it may be that there is something different about how corequisite courses and non-corquisite courses are taught that accounts for these observed effects. Similarly, it may be that motivationally, non-corequisite courses are experienced as more supportive than corequisite courses. In order to examine this possibility, it is important to understand the learning mindsets of students enrolled in these courses.

**Why Does This Research Matter?**

Our descriptive analyses indicate that compared to White and continuing-generation students, the proportion of Black, Latinx, Indigenous and first-generation students enrolled in corequisite courses is significantly higher. Prior research has indicated that learning mindsets (e.g., growth mindset, sense of belonging) may be especially related to outcomes for these students.[7] [8] Therefore, it is important to examine if the same is true for students enrolled in corequisite courses. Exploring if learning mindsets are salient predictors of future success among corequisite students, and furthermore, if there are specific learning mindsets that are more important than others, can better inform how educators should employ corequisite models of education. To do so, we must first explore how learning mindsets are related to academic outcomes in the current sample, and then examine if some of these learning mindsets are particularly important for the success of corequisite students.

**Research questions and purpose**

**Research Question 1:** How do learning mindsets relate to academic outcomes across all students?

**Research Question 2:** Are there specific mindsets that are more important for the academic success of students enrolled in corequisite courses (compared to students not enrolled in corequisite courses)?

**Purpose:** Although we know that learning mindsets are related to general learning outcomes in college (e.g., grades), less is known about how they operate in the context of corequisite models. In order to maximize the potential of corequisite education models, it is important to consider the short- and long-term effects of motivational beliefs (e.g., learning mindsets) on students' academic success within a corequisite setting. Thus, the purpose of this study is to investigate the relationship between students' learning mindsets and students' learning outcomes in their first year of college, particularly for students enrolled in at least one corequisite course, so that we can better support our students by creating more motivationally supportive environments in the future.

**Results and Key Findings**

**Research Question 1:** How do learning mindsets relate to academic outcomes across all students?

**Influence of Mindset**

Previous research has shown that student mindsets upon college entry can be used to predict their future academic performance. We therefore began our investigation by examining how students' growth mindset, belonging uncertainty, feelings of purpose and relevance, and perceived faculty mindset related to academic outcomes (overall GPA, pass rate for lead courses and second-semester retention). As in previous models and described above, we controlled for the student characteristics (e.g., race/ethnicity, generational status, gender) in all of our models to ensure that any associations of student mindsets with these variables would not serve as alternative explanations for observed relations of student mindsets with outcomes.

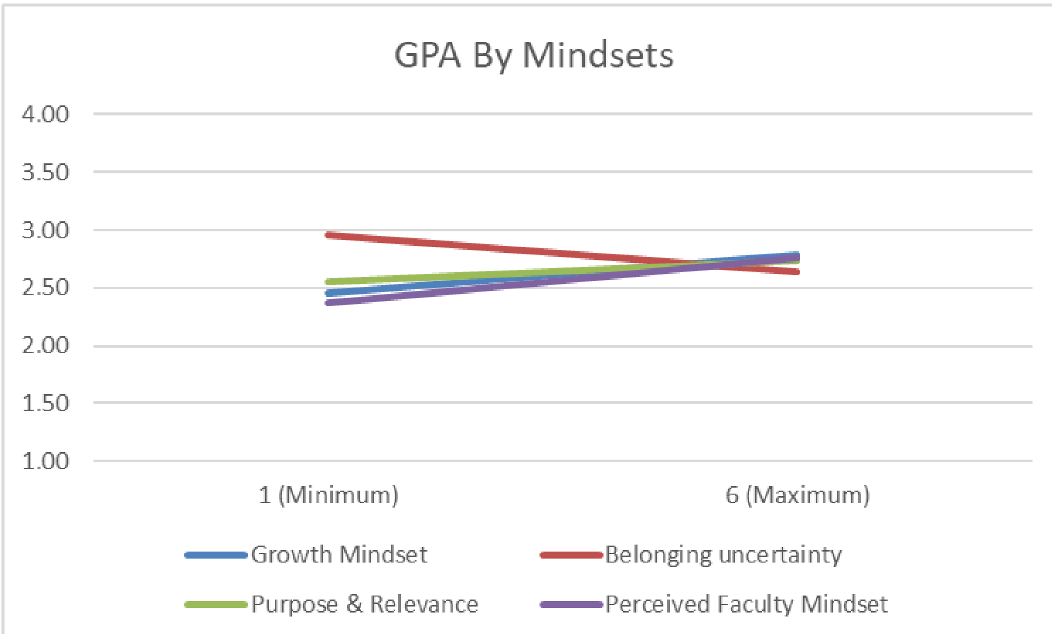
**Predicting GPA for all first semester courses from mindset**

Figure 5 below illustrates the relations of student mindsets with their overall GPA during their first semester (fall 2018). We observed the following significant relationships.

- Students with growth mindsets had higher GPAs than students with lower growth mindsets.
- Students that perceived high levels of purpose and relevance had higher GPAs than students who perceived low levels of purpose and relevance.

- Students low on belonging uncertainty had higher GPAs than students high on belonging uncertainty.
- Students who perceived their faculty as endorsing more of a growth mindset had higher GPAs than students who perceived their faculty as endorsing less of a growth mindset.

**Figure 5.** *Overall Fall 2018 GPA by student mindsets.*

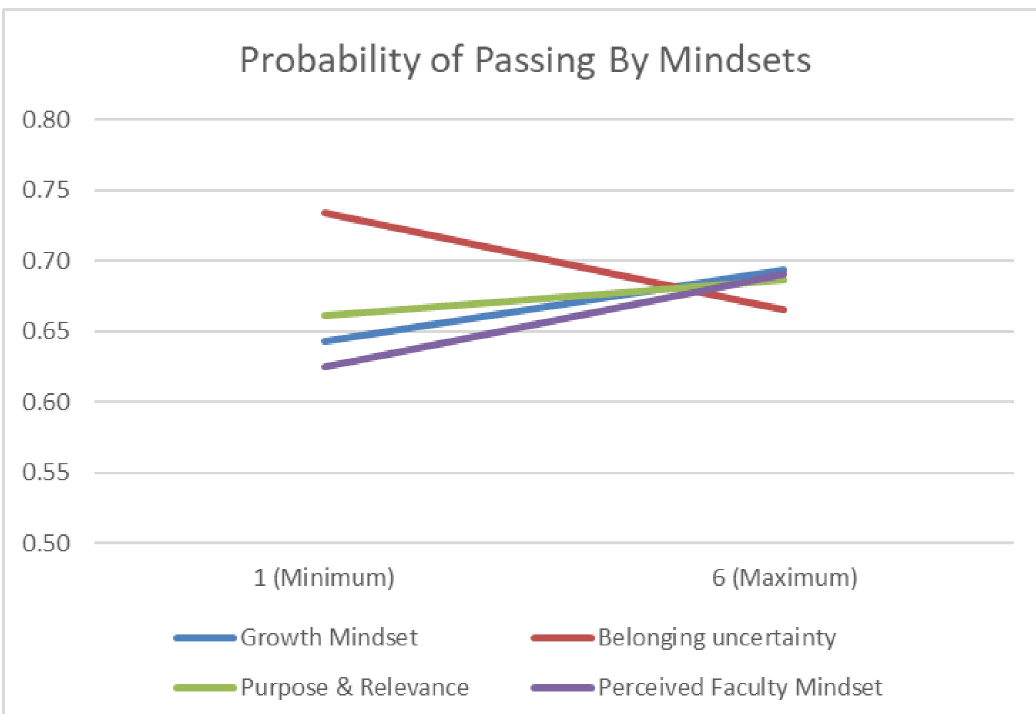


**Predicting pass rates for first semester lead courses**
Figure 6 below illustrates the relations of student mindsets with the likelihood that students passed lead courses during their first semester. We observed the following significant relationships.

- Students with higher growth mindset passed their lead course at a higher rate than students with lower growth mindset.
- Students low on belonging uncertainty passed their lead course at a higher rate than students high on belonging uncertainty.
- Students who perceived their faculty as possessing higher growth mindset passed their lead course at a higher rate than students who perceived their faculty as having lower growth mindset.

Although it appears that students high in perceptions of purpose and relevance passed their lead course at higher rates than those low in perceptions of purpose and relevance, this relationship was not strong enough to be significant in our analyses.

**Figure 6.** *Fall 2018 lead course pass rates by student mindsets.*



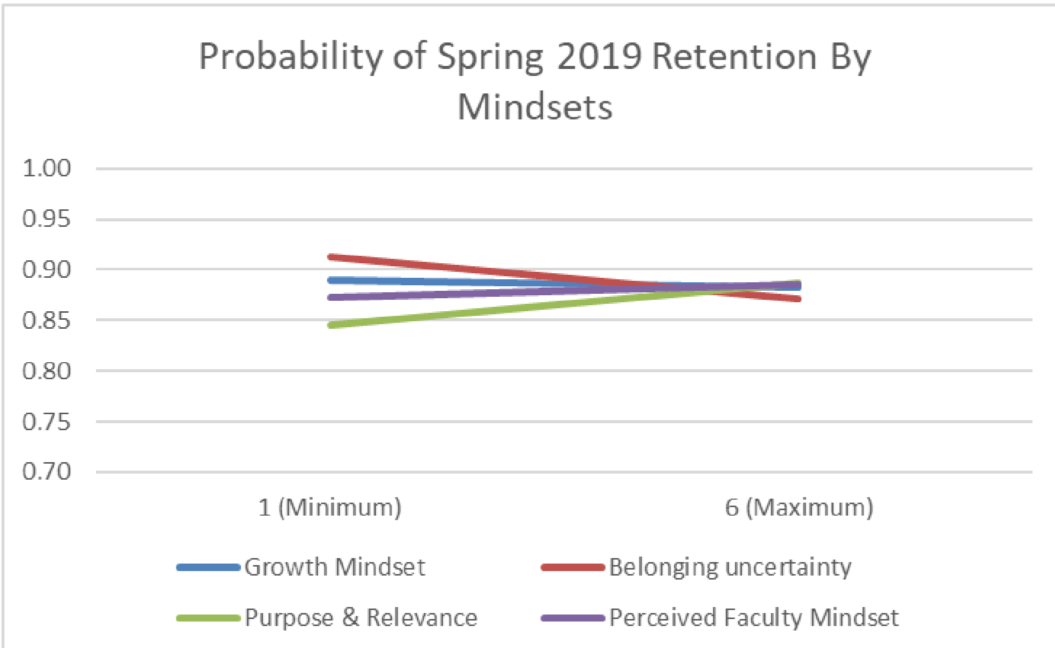

**Predicting Spring 2019 retention**
Figure 7 illustrates the relations of student mindsets with the likelihood that students would continue attending college during their second semester (i.e., spring 2019 retention). We observed the following significant relationships.

- Students who perceived high levels of purpose and relevance had higher retention rates than students who perceived less purpose and relevance.

- Students low on belonging uncertainty had higher retention rates than students high on belonging uncertainty.
- Students who perceived their faculty as possessing higher growth mindset had higher retention rates than students who perceived their faculty as having lower growth mindset.

Student growth mindset was not related to second semester retention.

**Figure 7.** *Spring 2019 retention rates by student mindsets.*




**Research Question 2:** Are there specific mindsets that are more important for the academic success of students enrolled in corequisite courses (compared to students not enrolled in corequisite courses)?

**Differential effects of mindset**

The prior analyses demonstrate that student mindsets are related to all three of the academic outcomes considered in this study (GPA, pass rate and retention). Up until now, however, we made the assumption that mindsets were equally important for all types of students. Given our focused interest in students taking corequisite courses, an important question is whether the relations of student mindsets with academic outcomes differ between corequisite and non-corequisite students. In the analyses below, we again control for race/ethnicity, student gender, student generation status, and the interactions of these characteristics with student mindsets to remove the possibility that student demographics might act as an alternative explanation for any interactions we observe between corequisite status and student mindsets on our outcomes. That is, we parse out the impact on outcomes that may be due to race/ethnicity, gender and generational status, to ensure that these factors do not explain observed effects between learning mindsets, corequisite status and the learning outcomes.

**Differential effects of mindset on GPA for students enrolled in corequisite courses versus students not enrolled in corequisite courses**

Our analyses indicated that the relations of student growth mindset and feelings of purpose and relevance with overall first-semester GPA did not significantly differ between students enrolled in corequisite courses and students not enrolled in corequisite courses. However, we did observe a significant effect of corequisite status on the relation of belonging uncertainty with GPA, which is illustrated in Figure 8. It appears that belonging uncertainty creates greater difficulties for corequisite students than non-corequisite students. That is, the negative effect of belonging uncertainty was particularly harmful for students enrolled in corequisite courses. We also observed a significant effect of corequisite status on the relation of perceived faculty mindset with GPA, which is illustrated in Figure 9. It appears that perceiving faculty to have a growth mindset is more beneficial for corequisite students than non-corequisite students. Another way of conceptualizing this effect is to think that the negative effects of perceiving an instructor as having a "fixed" mindset is particularly harmful for students enrolled in corequisite courses (and although still harmful, less harmful for students who are not enrolled in corequisite courses).

**Figure 8.** *Effects of belonging uncertainty and corequisite status on GPA.*

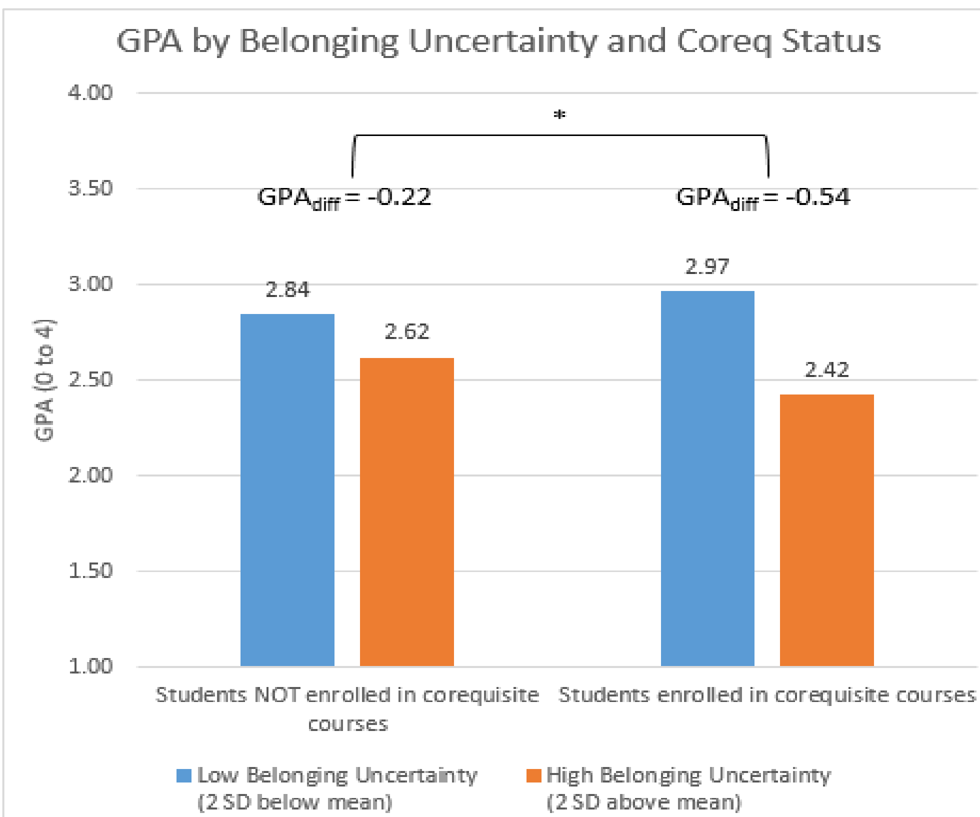
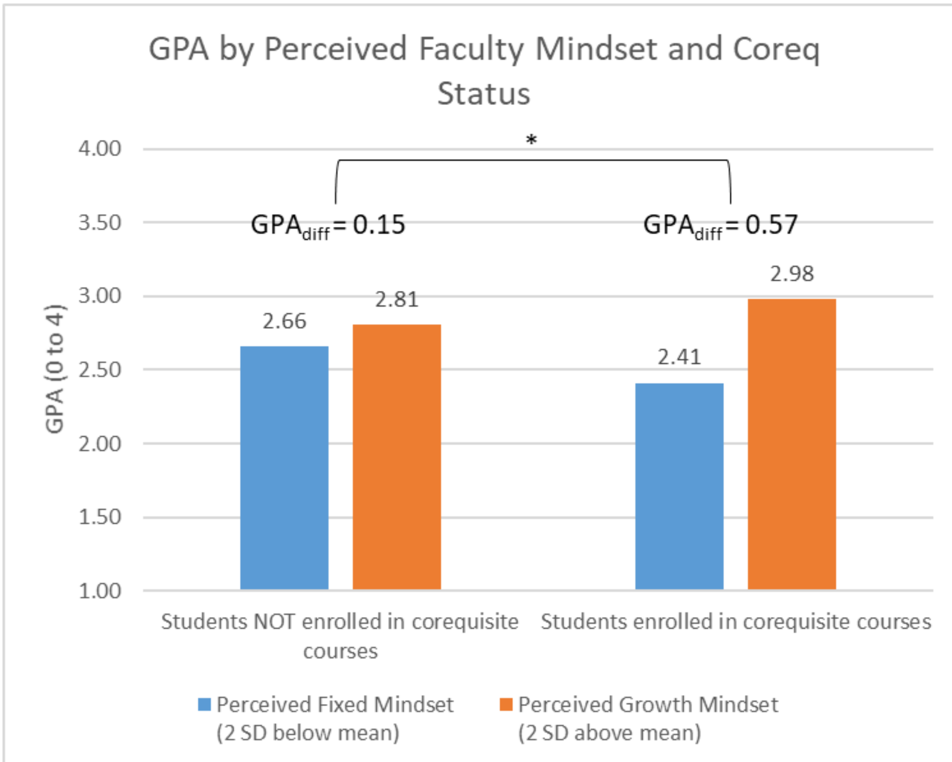


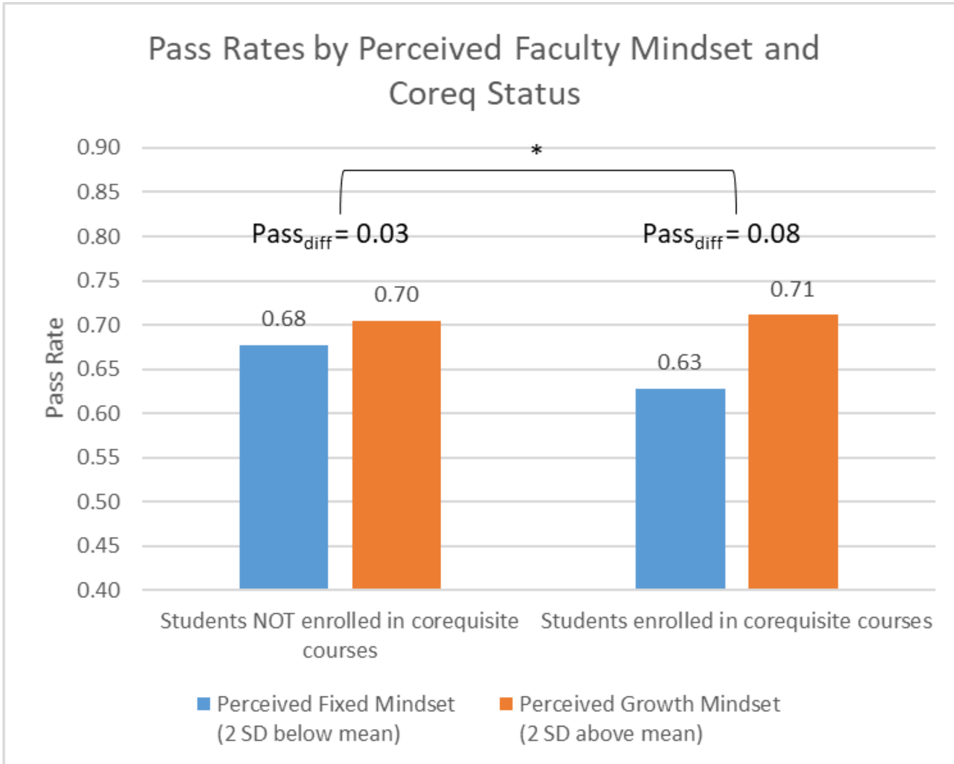
**Figure 9.** *Effects of perceived faculty mindset and corequisite status on GPA.*




**Differential effects of mindset on lead course pass rates for students enrolled in corequisite courses versus students not enrolled in corequisite courses**

Our analyses indicated that the relations of student growth mindset, belonging uncertainty, and feelings of purpose and relevance with lead course pass rates did not significantly differ between students enrolled in corequisite courses and students not enrolled in corequisite courses. However, we did observe a significant effect of corequisite status on the relation of perceived faculty mindset with pass rates, which is illustrated in Figure 10. It appears that having faculty with higher growth mindset is more beneficial for corequisite students than non-corequisite students. That is, students enrolled in corequisite courses are particularly likely to benefit (i.e., they may benefit more so than students not enrolled in corequisite courses), in terms of their pass rates, from perceiving their instructor to endorse a growth mindset.

**Figure 10.** *Effects of perceived faculty mindset and corequisite status on lead course pass rates.*




**Differential effects of mindset on spring 2019 retention for students enrolled in corequisite course versus students not enrolled in corequisite courses**

Our analyses indicated that the relations of student growth mindset, belonging uncertainty, and feelings of purpose and relevance with Spring 2019 retention rates did not significantly differ between corequisite and non-corequisite students. However, we did observe a significant effect of corequisite status on the relation of perceived faculty mindset with retention, which is illustrated in Figure 11. It appears that having faculty with growth mindsets is more beneficial for corequisite students than non-corequisite students. That is, students enrolled in corequisite courses are especially likely to benefit, in terms of retention, from perceiving their instructors to endorse a growth mindset (i.e., more so than students who are not enrolled in corequisite courses).

**Figure 11.** *Effects of perceived faculty mindset and corequisite status on second-semester retention rates.*

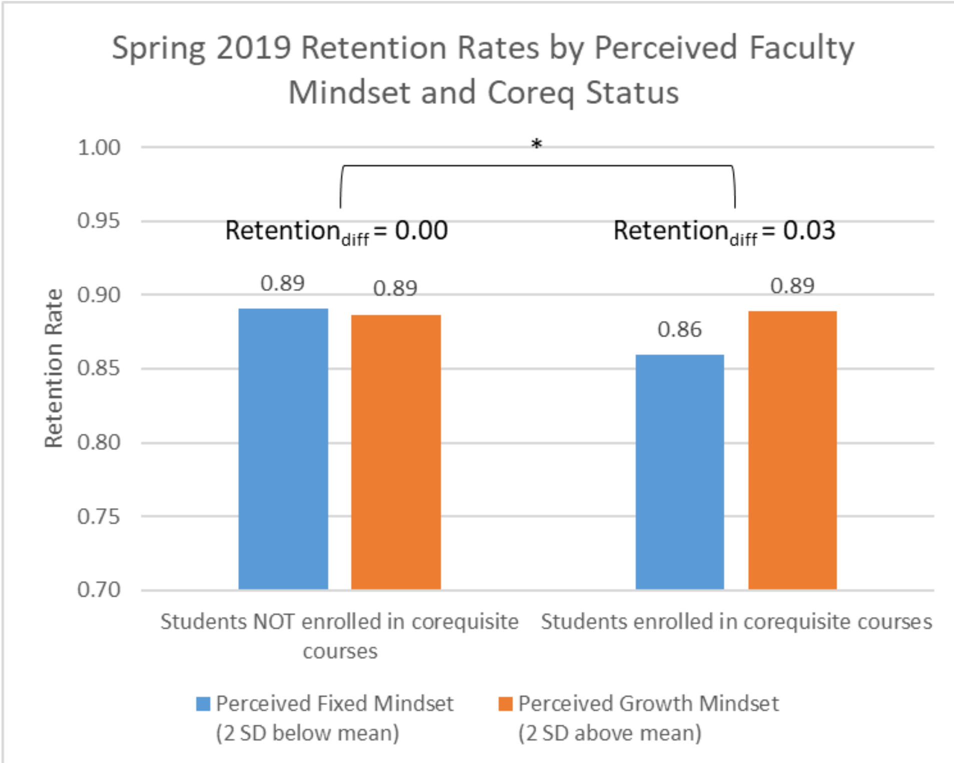



Table 2 captures the significant main effects and interactive effects of learning mindsets on academic outcomes as a function of corequisite status.

**Table 2.** *Significant Effects of Learning Mindsets on Academic Outcomes.*

| | Academic Outcome | | |
|---|---|---|---|
| **Learning Mindset** | **Fall 2018 GPA** | **Fall 2018 Lead Course Pass Rate** | **Spring 2019 Retention** |
| **Growth Mindset** | ↑ | ↑ | · |
| **Purpose & Relevance** | ↑ | · | ↑ |
| **Belonging Uncertainty** | ↓ | ↓ | ↓ |
| **Perceptions of Instructor Growth Mindset** | ↑ | ↑ | ↑ |

***Note:*** A green arrow (↑) indicates a significant positive relationship between the learning mindset and academic outcome. A red arrow (↓) indicates a significant negative relationship between the learning mindset and the outcome. The cells highlighted with blue indicate that the effect was particularly strong among students enrolled in corequisite courses (i.e., the relationship between the learning mindset and academic outcome is stronger among students enrolled in corequisite courses compared to students who are not enrolled in corequisite courses). A dot ( · ) indicates no statistically significant relationship between the learning mindset and the outcome. In all regression models, race/ethnicity, generational status, gender and prior academic performance were controlled for (i.e., entered into analytic models as covariates) to account for their effects on academic outcomes. Including these covariates removes the possibility that the observed effects may be due to these factors, providing more confidence that the observed relationships between learning mindsets and academic outcomes are authentic.

**Discussion**

The current study highlights that, consistent with prior research, learning mindsets play a critical role in supporting student learning and retention.[53 28] On average, students in our sample achieved higher GPAs and were more likely to pass their courses when they possessed higher levels of growth mindset, were less uncertain about their belonging to their institution, and perceived their faculty as possessing higher levels of growth mindset. Similarly, students who had stronger feelings that their courses possessed purpose and relevance, and students who were less uncertain about their belonging, were more likely to stay enrolled into the second semester.

Interestingly, our analyses also revealed that two learning mindsets – belonging uncertainty and perception of instructor growth mindset – showed stronger effects for students enrolled in corequisite courses, compared to students not enrolled in corequisite courses. Both belonging uncertainty and perception of instructor mindset were more strongly related to overall GPA for corequisite students (see Figures 7 and 8). Similar patterns emerged when evaluating pass rates and retention. Perception of instructor growth mindset was more strongly related to pass rates and belonging uncertainty was more strongly related to retention among students enrolled in corequisite courses when compared to their peers.

The effects on GPA suggests that the negative effects of being uncertain about belonging at the institution or perceiving instructors to have a fixed mindset were particularly pronounced for students enrolled in corequisite courses (see Figures 6 and 7). Equally troubling, students enrolled in corequisite courses *started* the semester with higher levels of belonging uncertainty and lower levels of perceived faculty growth mindset (see Figure 3). Thus, the students who would benefit most from feeling *less* belonging uncertainty or perceiving *more* faculty growth mindset (e.g., students enrolled in corequisite courses) actually report feeling *more* uncertain and perceive *less* faculty growth mindset than their peers. This may be related to developmental education often being stigmatized as intended for "underprepared" students.[54] Historically, the way institutions have marketed their developmental education programs have encouraged a deficit framing around the need to "remediate at-risk and underprepared" students. In traditional "prerequisite remedial" programs, students commonly attend courses for no credit.[2] Therefore, it is unsurprising that students enrolled in corequisite courses, which have historically granted no credit and been stigmatized as being for "not college-ready" students,[55] report feeling uncertain about their belonging in college. These same students are also more likely to perceive lower levels of growth mindset from their instructors (i.e., they are more likely to perceive their instructor as possessing "fixed" mindset characteristics; see Figure 3). This is unfortunate, as the correlation between perception of instructor growth mindset and belonging uncertainty ($r$ = -.30) suggests it is possible that perceiving your instructor to have a growth mindset could ameliorate the negative effects of a student's belonging concerns.[56]

Given how impactful these mindsets are on learning outcomes (e.g., GPA), these findings suggest that cultivating corequisite learning climates that mitigate belonging uncertainty and incorporate teaching strategies that lead to students perceiving higher levels of growth mindset from their instructors could be particularly effective for supporting students enrolled in corequisite courses. This focus on changing the context to be more motivationally supportive, rather than targeting an individual student's motivation is also consistent with nascent research suggesting that mindset research may further benefit from focusing more explicitly on contextual factors (e.g., teaching practices, situational cues, the marketing of corequisite courses, feedback mechanisms).[50] Indeed, we believe that instead of trying to instill learning mindsets into students in order to "fix" them, a more sustainable approach to fully leveraging the power of learning mindsets involves targeting learning environments to turn them into more motivationally supportive climates. Our findings suggest that implementing systemic changes that create more belonging-supportive learning environments where instructors showcase their belief in their students' abilities and intelligence would support the development of all students and students enrolled in corequisite courses in particular. From a sustainability standpoint, this more systemic approach of focusing on learning environments represents a more scalable way of leveraging both the power of learning mindsets and new models of corequisite education.

**Recommendations**

These findings also carry critical implications for the future of studying corequisite models and learning mindsets. In terms of concrete recommendations for researchers and practitioners, three key tenets emerge from our results:

1. **Measuring learning mindsets, particularly in corequisite models, should be encouraged.** Measuring learning mindsets builds awareness about their importance, enabling the field to track progress over time and gain a better understanding of how to create more motivationally supportive climates. Given that some mindsets (e.g., belonging uncertainty, perceived faculty growth mindset) were particularly strong predictors of academic outcomes among corequisite students, administering learning mindset measures in corequisite models feels especially relevant. In terms of measuring learning mindsets, there are accessible ways for educators to implement valid and reliable measures of learning mindsets. The Student Experience Research Network (formerly the Mindset Scholars Network) has curated a compendium of studies and measures that utilize learning mindset scales.[57] A core principle of improvement science, a methodology focused on continuously improving our educational systems, is that you cannot improve what you are not measuring.[58] By utilizing pragmatic measurement,[59] researchers and practitioners can administer brief but robust learning mindset measures, capable of predicting both short term (e.g., grades) and longer-terms (e.g., retention) outcomes. Administering these measures at critical time points during a student's tenure (i.e., key transition periods, like the beginning of a new school year) and tracking them over time will provide insights into which mindsets are most important for particular groups of students. It is also imperative that we disaggregate our data by different student factors, like corequisite status, race/ethnicity, generational status and gender to better understand how the effects of learning mindsets vary across students. For example, had we not chosen to investigate if learning mindsets operate differently for students enrolled in corequisite courses, we would not have discovered that belonging uncertainty and perception of instructor mindset are particularly important for the outcomes of students enrolled in corequisite courses.

Collecting learning mindset data is also important from an awareness-building perspective. A necessary first step for leveraging any of the current findings is to build awareness about the importance of learning mindsets among education practitioners (e.g., faculty, policy-makers, system leads). Many practitioners remain unaware of the impact of learning mindsets on student outcomes. Research has consistently shown that academic performance is not just a product of how "smart" a student is, but rather the interaction of multiple factors, including the extent to which the learning context supports motivation. Making this more visible to educators may compel them to critically evaluate their teaching practices and policies through a motivational lens. Indeed, building awareness around the importance and malleability of learning mindsets can be a first step toward larger adoption of motivationally supportive practices.

2. **Focus on targeting the corequisite environment and how it can support learning mindsets.** Historically, the way institutions have marked their developmental education programs has encouraged a deficit framing around the need to "remediate at-risk and underprepared students." Rather than trying to "fix" students to be more motivated, we advocate for targeting the learning environments to turn them into more motivationally supportive climates. Our findings suggest that implementing systemic changes that create more belonging and supportive learning environments – where instructors showcase their belief in their students' abilities and intelligence – could support the development of all students and students enrolled in corequisite courses in particular. Consider how educators can create learning environments that enable students to actualize their full potential; a potential that is more likely to be achieved when the optimal motivational environment is in place. We should equip educators with strategies that convey to their students that they are teaching from a growth mindset perspective.

   Emerging research[52] consistently demonstrates that students perform better when they believe their instructor has a growth mindset about student learning. For example, preparing educators with the skills necessary to convey growth-mindset supportive messages (i.e., praise effort not results, consider how feedback is framed, create opportunities for students to observe their own growth and development through challenges) may be particularly effective for students enrolled in corequisite courses. Similarly, the history of "remedial" education efforts leading to students feeling stigmatized and not "college material"[15] may be one reason why students enrolled in corequisite courses report higher levels of belonging uncertainty. To address this, efforts should be placed on destigmatizing developmental education and supporting students to feel like they belong because they *truly are* college material. Conveying to students enrolled in corequisite courses that the majority of college students doubt their belonging at times, but that these feelings of non-belonging typically dissipate over time, is one of several belonging-supportive strategies that educators could consider.[60] It is not surprising that the two learning mindsets most related to academic outcomes among students enrolled in corequisite courses (belonging uncertainty and perceptions of instructor growth mindset) are predicated on how a student feels about their academic environment. Clearly, for these students in particular, it is important to address the learning environment.

3. **Leverage data to target specific learning mindsets when implementing changes.** Learning mindset data can be used to inform what kinds of strategies can be implemented to support different groups of students. For example, although the learning mindsets measured in this report are all related to important academic outcomes (e.g., GPA), our findings indicate that specific learning mindsets are more salient in specific learning contexts. In particular, because belonging uncertainty and perceptions of faculty growth mindset are particularly important in corequisite courses, employing practices in corequisite courses that target these mindsets in particular may be especially beneficial. For example, to help reduce students' uncertainties about belonging, instructors could be trained to eliminate messages of non-belonging that students receive in syllabi and course materials. To help convey that the instructor believes in each student's potential to learn (e.g., increase perceptions of instructor growth mindset), instructors could offer opportunities to learn from mistakes and challenges.

4. **Integrate learning mindset supportive strategies into existing equitable system change efforts.** Historically, strategies that target growth mindset, purpose and relevance, and belonging uncertainty have also been effective at supporting historically marginalized students (e.g., Black, Latinx, Indigenous, first-generation college students). Thus, implementing learning mindset supportive practices has multiple benefits: In addition to being particularly effective for supporting historically marginalized students, the present research also indicates that they may be especially effective for supporting students enrolled in corequisite courses. Similar to how targeting learning mindsets may be especially beneficial in corequisite courses, we advocate for embedding learning mindset strategies into other existing reform efforts. For example, professional development for faculty could be offered as a part of on-going support for corequisite course instructors. Furthermore, connecting these improvement efforts to institutionally established structures for faculty recognition, such as annual review, increase the value for faculty to engage in such professional development efforts.

## Challenges

**Generating institutional buy-in is an important step toward leveraging the potential of learning mindsets.** As mentioned earlier, norming measurement of learning mindsets has the potential to increase awareness and inform data-driven strategies for supporting student motivation. However, not all practitioners have likely "bought-in" on this approach … yet. Showing these practitioners that motivation matters, and providing them with resources that highlight how the relationship between motivation and educational outcomes is as strong as the relationship between academic skills and outcomes,[61] [62] may entice reluctant educators to more critically consider how they support students. Furthermore, leveraging data from their own students to show the impact of learning mindsets may be another way of compelling practitioners to attend to the value of learning mindsets. Often, data is dismissed because it was collected and analyzed elsewhere, and educators can make the argument that "those data are from students that are different than mine." However, if local data can be leveraged to show relevant relationships between motivation or learning mindsets and outcomes, it makes it more difficult to dismiss findings and more likely that practitioners will consider the implications.

**Identifying which learning mindset strategy to implement can be tricky**. Ideally, data is utilized to inform decision-making, but sometimes data is lacking and educators are eager to implement. Consulting which learning mindset strategies have been vetted by the What Works Clearinghouse can familiarize educators with potential ideas for implementation. Finally, ongoing professional development opportunities that focus on student motivation are showing promise and becoming more popular, including faculty courses focused on leveraging learning mindset principles and micro-credentialing courses that focus on improving student engagement.

**Engaging student and faculty participation in data collection efforts can be challenging.** Despite including over 9,500 student participants in the current sample, our survey response rate was low (20%). Identifying strategies for incentivizing student participation either through granting credit or offering financial compensation may warrant further investigation. Similarly, given the newfound emphasis on instructor mindsets, future research needs to investigate best strategies for encouraging instructors to participate in learning mindset data collection efforts.

**Limitations**

It is important to note that the current report is based on correlational data. Although our data is not cross-sectional in that learning mindsets were first measured at the beginning of the semester, and academic outcomes were collected at the end of the semester, we should not over-interpret correlational findings. For example, we would be more confident in a causal link between the learning mindsets of students enrolled in corequisite courses and their outcomes if we experimentally manipulated the extent to which these learning mindsets existed in corequisite classes. Laboratory studies that have successfully manipulated students' perception of instructor growth mindset have explicated a causal link between perception of instructor growth mindset and academic performance,[50] [52] and future research may want to replicate these experimental findings in a field study. Similarly, other interventions that employ rigorous experimental methods (e.g., randomized controlled trials) based on the tenets of growth mindset, purpose and relevance, and sense of belonging have proven particularly successful at supporting students from historically marginalized backgrounds that comprise the majority of our corequisite sample.[63] [64] [65]

**Conclusion**

Learning mindsets significantly impact the outcomes of all students. Interestingly, learning mindsets that incorporate perceptions of the learning environment (e.g., belonging uncertainty, perception of instructor growth mindset) are particularly impactful for students enrolled in corequisite courses. These findings suggest that shifting learning mindset efforts toward modifying the learning environment (and/or perceptions of the learning environment) has the potential to benefit all students, with potentially larger positive impacts for students enrolled in corequisite courses. Researchers and practitioners should be asking themselves, "How can we create environments that reduce belonging concerns that students feel?" Similarly, efforts should be put toward training educators how to convey that they believe in students' abilities to grow and learn in their classrooms. Finally, as corequisite and mindset research continues to develop, it is imperative that we track learning mindsets and their relationships with student outcomes so that we are positioned to make data-driven decisions regarding the motivational climates we, as educators, are responsible for creating.

## Appendix

### Data and methods

### Participants and Procedure

We collected data from first-time freshmen at public higher education institutions in the Southeastern United States that implemented corequisite course models in their offerings – 13 two-year institutions in Tennessee and 18 four-year institutions in Georgia. Students were able to opt-in to complete the survey through a web link delivered by their institution, but were not otherwise incentivized for their participation. Data for this study was from 9,613 students who completed the survey during the Fall 2019 semester and for whom we could access administrative grade data from their respective institutional research departments (65.1% female, 56.7% first-generation, 53.3% White/Caucasian, 29.8% Black/African-American, 10.5% Latinx, 3.1% Multi-racial, 1.9% Asian and less than 1% each of other races/ethnicities).

### Measures

Measures included demographic questions and students' reported growth mindset,[30] purpose & relevance,[66] belonging uncertainty[65] and their perceptions of their faculties' growth mindset.[50] All items were asked on a 6-point Likert scale (1 = Strongly disagree to 6 = Strongly agree). Sample items and reliabilities can be seen in Table 1, descriptive statistics can be seen in Table 2.

### Administrative Data

Administrative data was obtained from institutional research departments from our partner education systems and included student demographics as well as semester-level and course-level student achievement data. Student corequisite status was coded from the course-level data such that students who were enrolled in at least one section of a learning support course were considered to be enrolled in corequisite courses. Lists of corequisite courses and their corresponding lead courses were obtained from both the Georgia and Tennessee higher education systems. These lists were then compared to the course schedules for each student in the Fall 2018 semester. These lists were also used to identify the lead courses for the calculation of the lead course pass rates.

**Table 1.** *Sample items and reliabilities for psychological constructs of interest.*

| Construct | Sample item | $\alpha_{overall}$ | $\alpha_{coreq}$ | $\alpha_{non\text{-}coreq}$ |
|---|---|---|---|---|
| **Growth Mindset** | "You can learn new things, but you can't really change your basic [math/English] intelligence." *(reverse-scored)* | 0.87 | 0.87 | 0.87 |
| **Purpose & Relevance** | "What I learn in my [math/English] classes will be useful in the future." | 0.87 | 0.86 | 0.87 |
| **Belonging Uncertainty** | "Sometimes I feel that I belong at college, and sometimes I feel that I don't belong at college." | 0.71 | 0.70 | 0.71 |
| **Perception of Instructor Mindset** | "The instructors at my college/university seem to believe that students have a certain amount of intelligence, and they really can't do much to change it." *(reverse-scored)* | 0.87 | 0.85 | 0.86 |

**Table 2.** *Correlations for variables of interest.*

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1. Corequisite Status | – | | | | | |
| 2. Growth Mindset | -0.06*** | – | | | | |
| 3. Purpose & Relevance | 0.07*** | 0.04** | – | | | |
| 4. Belonging Uncertainty | 0.05*** | -0.29*** | -0.10*** | – | | |
| 5. Student Perceptions of Faculty GM | -0.06*** | 0.56*** | 0.15*** | -0.30*** | – | |
| 6. High School GPA | -0.44*** | 0.14*** | -0.02 | -0.07*** | 0.12*** | – |
| 7. Lead Course GPA | -0.24*** | 0.13*** | -0.01 | -0.09*** | 0.11*** | 0.44*** |

**Table 3.** *Demographic frequencies by coreq status.*

A) Race

| Race/Ethnicity | Corequisite status | Frequency | Percent |
|---|---|---|---|
| Asian | Not coreq | 137 | 1.4% |
| | Coreq | 48 | 0.5% |
| Black | Not coreq | 1,593 | 16.6% |
| | Coreq | 1,254 | 13.1% |
| Indigenous | Not coreq | 12 | 0.1% |
| | Coreq | 12 | 0.1% |
| LatinX | Not coreq | 567 | 5.9% |
| | Coreq | 434 | 4.5% |
| Native Hawaiian/Pacific Islander | Not coreq | 2 | 0.0% |
| | Coreq | 4 | 0.0% |
| White | Not coreq | 3,636 | 38.0% |
| | Coreq | 1,478 | 15.4% |
| Multiracial | Not coreq | 185 | 1.9% |
| | Coreq | 114 | 1.2% |

B) Gender

| Gender | Corequisite status | Frequency | Percent |
|---|---|---|---|
| Female | Not coreq | 4,026 | 42.0% |
| | Coreq | 2,215 | 23.1% |
| Male | Not coreq | 2,152 | 22.5% |
| | Coreq | 1,183 | 12.4% |

C) Generation status

| Generation status | Corequisite status | Frequency | Percent |
|---|---|---|---|
| Continuing generation | Not coreq | 2,449 | 31.9% |
| | Coreq | 878 | 11.4% |
| First generation | Not coreq | 2,240 | 31.7% |
| | Coreq | 1,921 | 25.0% |

D) Pell grant status

| Pell grant status | Corequisite status | Frequency | Percent |
|---|---|---|---|
| Not a Pell grant recipient | Not coreq | 3,127 | 39.8% |
| | Coreq | 1,584 | 20.2% |
| Pell grant recipient | Not coreq | 1,835 | 23.3% |
| | Coreq | 1,314 | 16.7% |

**Table 4.** *Regression models.*

A) Fall 2018 GPA main effects

| Population | Subject | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|---|
| College | MathEng | Intercept | 2.740 | 0.062 | 0.000 | 2.627 | 0.117 | 0.000 |
| College | MathEng | ZTOI.1 | 0.076 | 0.019 | 0.000 | 0.072 | 0.016 | 0.000 |
| College | MathEng | priorPerf | 0.453 | 0.029 | 0.000 | 0.435 | 0.025 | 0.000 |
| College | MathEng | Female | 0.121 | 0.032 | 0.000 | 0.055 | 0.015 | 0.000 |
| College | MathEng | fg | -0.098 | 0.035 | 0.005 | -0.046 | 0.017 | 0.007 |
| College | MathEng | urm | -0.115 | 0.060 | 0.055 | -0.054 | 0.028 | 0.052 |
| College | MathEng | Intercept | 2.739 | 0.061 | 0.000 | 2.626 | 0.116 | 0.000 |
| College | MathEng | ZBel_unc.1 | -0.086 | 0.020 | 0.000 | -0.081 | 0.018 | 0.000 |
| College | MathEng | priorPerf | 0.454 | 0.030 | 0.000 | 0.436 | 0.026 | 0.000 |
| College | MathEng | Female | 0.131 | 0.031 | 0.000 | 0.060 | 0.014 | 0.000 |
| College | MathEng | fg | -0.089 | 0.033 | 0.007 | -0.042 | 0.016 | 0.009 |
| College | MathEng | urm | -0.136 | 0.059 | 0.021 | -0.064 | 0.027 | 0.019 |
| College | MathEng | Intercept | 2.750 | 0.062 | 0.000 | 2.637 | 0.116 | 0.000 |
| College | MathEng | ZPurpRel.1 | 0.028 | 0.012 | 0.016 | 0.027 | 0.011 | 0.015 |
| College | MathEng | priorPerf | 0.460 | 0.029 | 0.000 | 0.441 | 0.025 | 0.000 |
| College | MathEng | Female | 0.120 | 0.032 | 0.000 | 0.055 | 0.014 | 0.000 |
| College | MathEng | fg | -0.096 | 0.034 | 0.005 | -0.046 | 0.017 | 0.007 |
| College | MathEng | urm | -0.140 | 0.060 | 0.019 | -0.066 | 0.028 | 0.017 |
| College | MathEng | Intercept | 2.750 | 0.061 | 0.000 | 2.636 | 0.116 | 0.000 |
| College | MathEng | ZPerFac.1 | 0.079 | 0.017 | 0.000 | 0.074 | 0.014 | 0.000 |
| College | MathEng | priorPerf | 0.455 | 0.029 | 0.000 | 0.436 | 0.025 | 0.000 |
| College | MathEng | Female | 0.107 | 0.031 | 0.001 | 0.049 | 0.014 | 0.000 |
| College | MathEng | fg | -0.095 | 0.034 | 0.005 | -0.045 | 0.017 | 0.007 |
| College | MathEng | urm | -0.122 | 0.059 | 0.040 | -0.058 | 0.028 | 0.037 |

B) Fall 2018 DFW main effects

| Population | Subject | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|---|
| Lead | MathEng | ZTOI.1 | -0.052 | 0.017 | 0.002 | -0.051 | 0.016 | 0.001 |
| Lead | MathEng | priorPerf | -0.418 | 0.021 | 0.000 | -0.418 | 0.020 | 0.000 |
| Lead | MathEng | Female | -0.100 | 0.040 | 0.012 | -0.048 | 0.019 | 0.011 |
| Lead | MathEng | fg | 0.113 | 0.048 | 0.019 | 0.056 | 0.024 | 0.020 |
| Lead | MathEng | urm | -0.062 | 0.071 | 0.383 | -0.031 | 0.036 | 0.388 |
| Lead | MathEng | ZBel_unc.1 | 0.087 | 0.016 | 0.000 | 0.085 | 0.016 | 0.000 |
| Lead | MathEng | priorPerf | -0.417 | 0.021 | 0.000 | -0.417 | 0.020 | 0.000 |

| Population | Subject | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|---|
| Lead | MathEng | Female | -0.109 | 0.038 | 0.004 | -0.052 | 0.018 | 0.004 |
| Lead | MathEng | fg | 0.103 | 0.047 | 0.029 | 0.051 | 0.024 | 0.030 |
| Lead | MathEng | urm | -0.048 | 0.070 | 0.492 | -0.024 | 0.035 | 0.495 |
| Lead | MathEng | ZPurpRel.1 | -0.018 | 0.016 | 0.283 | -0.018 | 0.016 | 0.284 |
| Lead | MathEng | priorPerf | -0.423 | 0.021 | 0.000 | -0.423 | 0.020 | 0.000 |
| Lead | MathEng | Female | -0.098 | 0.039 | 0.011 | -0.047 | 0.018 | 0.011 |
| Lead | MathEng | fg | 0.110 | 0.048 | 0.023 | 0.054 | 0.024 | 0.024 |
| Lead | MathEng | urm | -0.047 | 0.071 | 0.507 | -0.023 | 0.036 | 0.511 |
| Lead | MathEng | ZPerFac.1 | -0.059 | 0.012 | 0.000 | -0.057 | 0.011 | 0.000 |
| Lead | MathEng | priorPerf | -0.419 | 0.021 | 0.000 | -0.419 | 0.020 | 0.000 |
| Lead | MathEng | Female | -0.088 | 0.039 | 0.025 | -0.042 | 0.019 | 0.025 |
| Lead | MathEng | fg | 0.109 | 0.048 | 0.024 | 0.054 | 0.024 | 0.025 |
| Lead | MathEng | urm | -0.059 | 0.072 | 0.410 | -0.029 | 0.036 | 0.414 |

C) Spring 2019 retention main effects

| Outcome | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|
| retainFa2019 | ZTOI.1 | 0.015 | 0.015 | 0.299 | 0.015 | 0.014 | 0.286 |
| retainFa2019 | priorPerf | 0.281 | 0.016 | 0.000 | 0.281 | 0.018 | 0.000 |
| retainFa2019 | Female | 0.089 | 0.023 | 0.000 | 0.042 | 0.011 | 0.000 |
| retainFa2019 | fg | -0.156 | 0.046 | 0.001 | -0.077 | 0.023 | 0.001 |
| retainFa2019 | urm | 0.051 | 0.055 | 0.347 | 0.025 | 0.027 | 0.350 |
| retainFa2019 | ZBel_unc.1 | -0.087 | 0.020 | 0.000 | -0.086 | 0.020 | 0.000 |
| retainFa2019 | priorPerf | 0.277 | 0.017 | 0.000 | 0.277 | 0.018 | 0.000 |
| retainFa2019 | Female | 0.098 | 0.023 | 0.000 | 0.047 | 0.011 | 0.000 |
| retainFa2019 | fg | -0.149 | 0.045 | 0.001 | -0.074 | 0.023 | 0.001 |
| retainFa2019 | urm | 0.047 | 0.053 | 0.382 | 0.023 | 0.027 | 0.385 |
| retainFa2019 | ZPurpRel.1 | 0.042 | 0.015 | 0.005 | 0.042 | 0.015 | 0.005 |
| retainFa2019 | priorPerf | 0.281 | 0.017 | 0.000 | 0.281 | 0.019 | 0.000 |
| retainFa2019 | Female | 0.086 | 0.024 | 0.000 | 0.041 | 0.011 | 0.000 |
| retainFa2019 | fg | -0.158 | 0.046 | 0.001 | -0.078 | 0.023 | 0.001 |
| retainFa2019 | urm | 0.039 | 0.054 | 0.473 | 0.019 | 0.027 | 0.475 |
| retainFa2019 | ZPerFac.1 | 0.044 | 0.012 | 0.000 | 0.043 | 0.012 | 0.000 |
| retainFa2019 | priorPerf | 0.280 | 0.017 | 0.000 | 0.280 | 0.018 | 0.000 |
| retainFa2019 | Female | 0.080 | 0.023 | 0.001 | 0.038 | 0.011 | 0.000 |
| retainFa2019 | fg | -0.154 | 0.046 | 0.001 | -0.076 | 0.023 | 0.001 |
| retainFa2019 | urm | 0.055 | 0.055 | 0.312 | 0.027 | 0.027 | 0.316 |

D) Fall 2018 GPA interactions

| Population | Subject | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|---|
| College | MathEng | Intercept | 2.752 | 0.060 | 0.000 | 2.639 | 0.115 | 0.000 |
| College | MathEng | ZTOI.1 | 0.081 | 0.034 | 0.017 | 0.074 | 0.031 | 0.016 |
| College | MathEng | coreq | -0.041 | 0.056 | 0.463 | -0.019 | 0.026 | 0.464 |
| College | MathEng | priorPerf | 0.444 | 0.025 | 0.000 | 0.426 | 0.024 | 0.000 |
| College | MathEng | fg | -0.089 | 0.033 | 0.007 | -0.042 | 0.016 | 0.009 |
| College | MathEng | urm | -0.119 | 0.057 | 0.038 | -0.056 | 0.027 | 0.035 |
| College | MathEng | Female | 0.121 | 0.033 | 0.000 | 0.055 | 0.015 | 0.000 |
| College | MathEng | coreqXZTOI.1 | 0.058 | 0.036 | 0.108 | 0.033 | 0.020 | 0.102 |
| College | MathEng | fgXZTOI.1 | 0.021 | 0.020 | 0.296 | 0.015 | 0.014 | 0.290 |
| College | MathEng | urmXZTOI.1 | -0.043 | 0.029 | 0.145 | -0.027 | 0.020 | 0.175 |
| College | MathEng | femaleXZTOI.1 | -0.026 | 0.023 | 0.244 | -0.019 | 0.016 | 0.242 |
| College | MathEng | Intercept | 2.752 | 0.059 | 0.000 | 2.638 | 0.114 | 0.000 |
| College | MathEng | ZBel_unc.1 | -0.097 | 0.022 | 0.000 | -0.086 | 0.018 | 0.000 |
| College | MathEng | coreq | -0.039 | 0.054 | 0.474 | -0.018 | 0.025 | 0.475 |
| College | MathEng | priorPerf | 0.444 | 0.026 | 0.000 | 0.426 | 0.024 | 0.000 |
| College | MathEng | fg | -0.079 | 0.032 | 0.015 | -0.037 | 0.016 | 0.018 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| College | MathEng | urm | -0.143 | 0.058 | 0.015 | -0.068 | 0.027 | 0.013 |
| College | MathEng | Female | 0.132 | 0.031 | 0.000 | 0.060 | 0.014 | 0.000 |
| College | MathEng | coreqXZBel_unc.1 | -0.080 | 0.023 | 0.000 | -0.042 | 0.012 | 0.001 |
| College | MathEng | fgXZBel_unc.1 | -0.017 | 0.026 | 0.516 | -0.011 | 0.017 | 0.517 |
| College | MathEng | urmXZBel_unc.1 | 0.076 | 0.027 | 0.005 | 0.041 | 0.016 | 0.009 |
| College | MathEng | femaleXZBel_unc.1 | 0.029 | 0.019 | 0.122 | 0.021 | 0.013 | 0.115 |
| College | MathEng | Intercept | 2.766 | 0.059 | 0.000 | 2.652 | 0.114 | 0.000 |
| College | MathEng | ZPurpRel.1 | 0.042 | 0.019 | 0.030 | 0.039 | 0.018 | 0.029 |
| College | MathEng | coreq | -0.050 | 0.055 | 0.357 | -0.023 | 0.025 | 0.358 |
| College | MathEng | priorPerf | 0.448 | 0.026 | 0.000 | 0.430 | 0.024 | 0.000 |
| College | MathEng | fg | -0.084 | 0.033 | 0.011 | -0.040 | 0.016 | 0.013 |
| College | MathEng | urm | -0.144 | 0.059 | 0.014 | -0.068 | 0.027 | 0.013 |
| College | MathEng | Female | 0.120 | 0.033 | 0.000 | 0.055 | 0.015 | 0.000 |
| College | MathEng | coreqXZPurpRel.1 | 0.036 | 0.022 | 0.096 | 0.019 | 0.012 | 0.096 |
| College | MathEng | fgXZPurpRel.1 | 0.028 | 0.025 | 0.268 | 0.019 | 0.017 | 0.270 |
| College | MathEng | urmXZPurpRel.1 | -0.056 | 0.018 | 0.002 | -0.033 | 0.012 | 0.006 |
| College | MathEng | femaleXZPurpRel.1 | -0.024 | 0.022 | 0.275 | -0.018 | 0.016 | 0.273 |
| College | MathEng | Intercept | 2.763 | 0.059 | 0.000 | 2.649 | 0.115 | 0.000 |
| College | MathEng | ZPerFac.1 | 0.083 | 0.025 | 0.001 | 0.072 | 0.022 | 0.001 |
| College | MathEng | coreq | -0.040 | 0.054 | 0.458 | -0.018 | 0.025 | 0.459 |
| College | MathEng | priorPerf | 0.446 | 0.026 | 0.000 | 0.428 | 0.024 | 0.000 |
| College | MathEng | fg | -0.085 | 0.033 | 0.009 | -0.041 | 0.016 | 0.011 |
| College | MathEng | urm | -0.128 | 0.058 | 0.027 | -0.061 | 0.027 | 0.025 |
| College | MathEng | Female | 0.108 | 0.032 | 0.001 | 0.049 | 0.014 | 0.001 |
| College | MathEng | coreqXZPerFac.1 | 0.104 | 0.032 | 0.001 | 0.055 | 0.017 | 0.001 |
| College | MathEng | fgXZPerFac.1 | 0.003 | 0.023 | 0.888 | 0.002 | 0.015 | 0.888 |
| College | MathEng | urmXZPerFac.1 | -0.061 | 0.023 | 0.009 | -0.035 | 0.014 | 0.013 |
| College | MathEng | femaleXZPerFac.1 | -0.033 | 0.020 | 0.101 | -0.023 | 0.014 | 0.101 |

E) Fall 2019 DFW interactions

| Population | Subject | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|---|
| Lead | MathEng | ZTOI.1 | -0.097 | 0.042 | 0.022 | -0.095 | 0.042 | 0.022 |
| Lead | MathEng | coreq | 0.091 | 0.076 | 0.230 | 0.044 | 0.036 | 0.229 |
| Lead | MathEng | priorPerf | -0.399 | 0.021 | 0.000 | -0.400 | 0.021 | 0.000 |
| Lead | MathEng | fg | 0.103 | 0.047 | 0.030 | 0.051 | 0.024 | 0.031 |
| Lead | MathEng | urm | -0.061 | 0.069 | 0.371 | -0.030 | 0.034 | 0.375 |
| Lead | MathEng | Female | -0.100 | 0.040 | 0.012 | -0.048 | 0.019 | 0.012 |
| Lead | MathEng | coreqXZTOI.1 | -0.046 | 0.028 | 0.101 | -0.027 | 0.016 | 0.097 |
| Lead | MathEng | fgXZTOI.1 | 0.010 | 0.028 | 0.716 | 0.008 | 0.021 | 0.716 |
| Lead | MathEng | urmXZTOI.1 | 0.046 | 0.025 | 0.063 | 0.030 | 0.016 | 0.064 |
| Lead | MathEng | femaleXZTOI.1 | 0.054 | 0.035 | 0.121 | 0.042 | 0.027 | 0.124 |
| Lead | MathEng | ZBel_unc.1 | 0.135 | 0.028 | 0.000 | 0.133 | 0.028 | 0.000 |
| Lead | MathEng | coreq | 0.092 | 0.074 | 0.217 | 0.044 | 0.036 | 0.216 |

| Population | Subject | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|---|
| Lead | MathEng | priorPerf | -0.397 | 0.021 | 0.000 | -0.397 | 0.021 | 0.000 |
| Lead | MathEng | fg | 0.092 | 0.047 | 0.049 | 0.046 | 0.023 | 0.050 |
| Lead | MathEng | urm | -0.043 | 0.068 | 0.524 | -0.021 | 0.034 | 0.527 |
| Lead | MathEng | Female | -0.112 | 0.037 | 0.003 | -0.053 | 0.018 | 0.003 |
| Lead | MathEng | coreqXZBel_unc.1 | 0.040 | 0.025 | 0.111 | 0.022 | 0.013 | 0.103 |
| Lead | MathEng | fgXZBel_unc.1 | 0.000 | 0.033 | 0.997 | 0.000 | 0.024 | 0.997 |
| Lead | MathEng | urmXZBel_unc.1 | -0.096 | 0.029 | 0.001 | -0.056 | 0.017 | 0.001 |
| Lead | MathEng | femaleXZBel_unc.1 | -0.044 | 0.033 | 0.180 | -0.033 | 0.025 | 0.182 |
| Lead | MathEng | ZPurpRel.1 | -0.036 | 0.029 | 0.204 | -0.036 | 0.029 | 0.206 |
| Lead | MathEng | coreq | 0.098 | 0.075 | 0.189 | 0.047 | 0.036 | 0.190 |
| Lead | MathEng | priorPerf | -0.402 | 0.022 | 0.000 | -0.402 | 0.022 | 0.000 |
| Lead | MathEng | fg | 0.099 | 0.047 | 0.036 | 0.049 | 0.023 | 0.037 |
| Lead | MathEng | urm | -0.046 | 0.069 | 0.505 | -0.023 | 0.034 | 0.508 |
| Lead | MathEng | Female | -0.102 | 0.038 | 0.008 | -0.049 | 0.018 | 0.008 |
| Lead | MathEng | coreqXZPurpRel.1 | -0.027 | 0.025 | 0.280 | -0.016 | 0.014 | 0.276 |
| Lead | MathEng | fgXZPurpRel.1 | 0.004 | 0.029 | 0.896 | 0.003 | 0.021 | 0.896 |
| Lead | MathEng | urmXZPurpRel.1 | 0.037 | 0.029 | 0.199 | 0.023 | 0.018 | 0.210 |
| Lead | MathEng | femaleXZPurpRel.1 | 0.014 | 0.033 | 0.668 | 0.011 | 0.026 | 0.668 |
| Lead | MathEng | ZPerFac.1 | -0.089 | 0.031 | 0.004 | -0.087 | 0.030 | 0.004 |
| Lead | MathEng | coreq | 0.093 | 0.075 | 0.214 | 0.045 | 0.036 | 0.213 |
| Lead | MathEng | priorPerf | -0.399 | 0.021 | 0.000 | -0.399 | 0.021 | 0.000 |
| Lead | MathEng | fg | 0.098 | 0.047 | 0.038 | 0.049 | 0.024 | 0.039 |
| Lead | MathEng | urm | -0.057 | 0.069 | 0.412 | -0.028 | 0.034 | 0.416 |
| Lead | MathEng | Female | -0.090 | 0.039 | 0.019 | -0.043 | 0.018 | 0.019 |
| Lead | MathEng | coreqXZPerFac.1 | -0.062 | 0.029 | 0.032 | -0.034 | 0.016 | 0.027 |
| Lead | MathEng | fgXZPerFac.1 | 0.021 | 0.034 | 0.539 | 0.015 | 0.024 | 0.538 |
| Lead | MathEng | urmXZPerFac.1 | 0.054 | 0.023 | 0.018 | 0.033 | 0.014 | 0.020 |
| Lead | MathEng | femaleXZPerFac.1 | 0.034 | 0.036 | 0.350 | 0.025 | 0.027 | 0.349 |

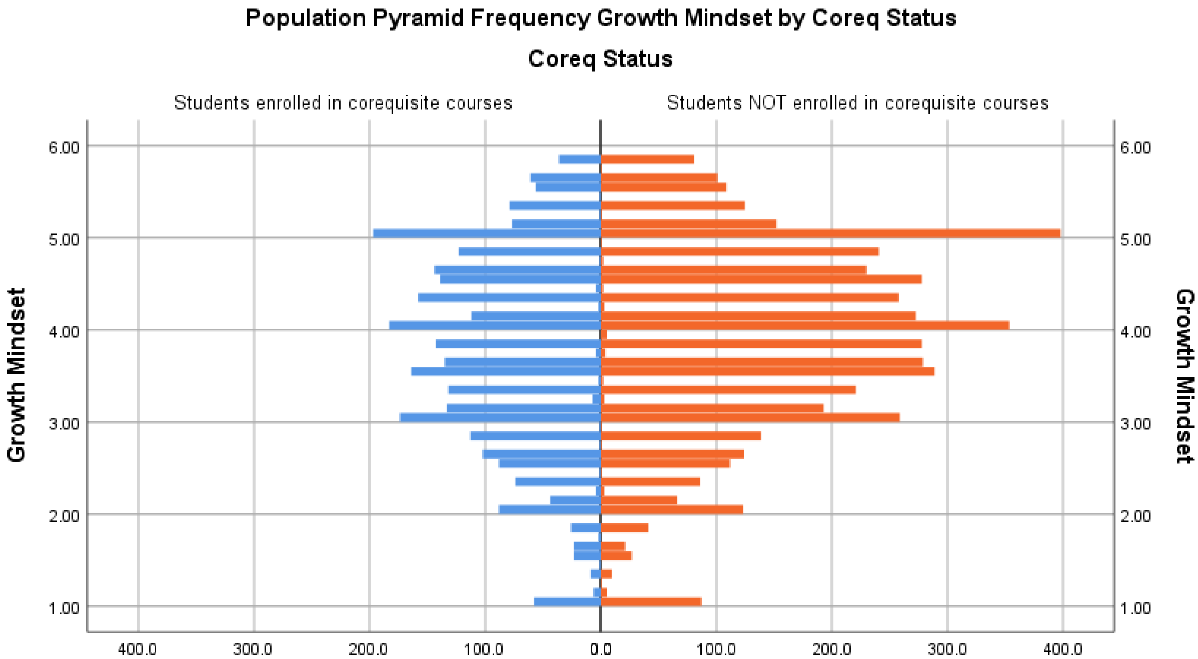
F) Spring 2019 retention interactions

| Outcome | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|
| retainSp2019 | ZTOI.1 | 0.009 | 0.038 | 0.812 | 0.009 | 0.038 | 0.811 |
| retainSp2019 | coreq | -0.133 | 0.053 | 0.012 | -0.063 | 0.025 | 0.012 |
| retainSp2019 | priorPerf | 0.207 | 0.027 | 0.000 | 0.207 | 0.028 | 0.000 |
| retainSp2019 | fg | -0.175 | 0.056 | 0.002 | -0.086 | 0.028 | 0.002 |
| retainSp2019 | urm | 0.155 | 0.070 | 0.027 | 0.076 | 0.035 | 0.029 |
| retainSp2019 | Female | 0.124 | 0.043 | 0.004 | 0.059 | 0.020 | 0.003 |
| retainSp2019 | coreqXZTOI.1 | 0.032 | 0.054 | 0.557 | 0.019 | 0.032 | 0.558 |
| retainSp2019 | fgXZTOI.1 | 0.020 | 0.029 | 0.505 | 0.015 | 0.022 | 0.504 |
| retainSp2019 | urmXZTOI.1 | -0.015 | 0.039 | 0.709 | -0.010 | 0.026 | 0.708 |
| retainSp2019 | femaleXZTOI.1 | -0.064 | 0.051 | 0.209 | -0.049 | 0.039 | 0.207 |
| retainSp2019 | ZBel_unc.1 | -0.148 | 0.048 | 0.002 | -0.145 | 0.048 | 0.002 |

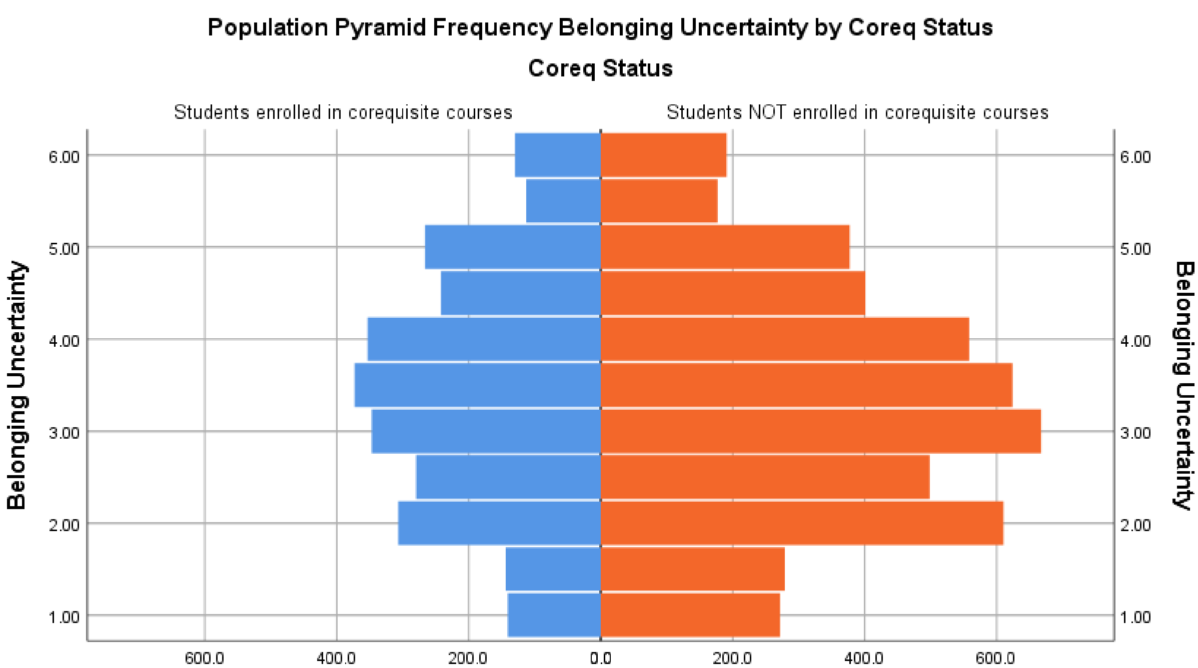
| Outcome | Predictor | b | b_SE | b_p | beta | beta_SE | beta_p |
|---|---|---|---|---|---|---|---|
| retainSp2019 | coreq | -0.135 | 0.051 | 0.008 | -0.065 | 0.025 | 0.008 |
| retainSp2019 | priorPerf | 0.197 | 0.027 | 0.000 | 0.197 | 0.028 | 0.000 |
| retainSp2019 | fg | -0.166 | 0.056 | 0.003 | -0.082 | 0.028 | 0.003 |
| retainSp2019 | urm | 0.154 | 0.070 | 0.027 | 0.076 | 0.035 | 0.030 |
| retainSp2019 | Female | 0.140 | 0.040 | 0.001 | 0.067 | 0.019 | 0.000 |
| retainSp2019 | coreqXZBel_unc.1 | 0.024 | 0.039 | 0.530 | 0.013 | 0.021 | 0.531 |
| retainSp2019 | fgXZBel_unc.1 | -0.024 | 0.041 | 0.555 | -0.017 | 0.029 | 0.556 |
| retainSp2019 | urmXZBel_unc.1 | 0.023 | 0.037 | 0.539 | 0.013 | 0.021 | 0.539 |
| retainSp2019 | femaleXZBel_unc.1 | 0.047 | 0.046 | 0.305 | 0.036 | 0.035 | 0.307 |
| retainSp2019 | ZPurpRel.1 | 0.136 | 0.030 | 0.000 | 0.137 | 0.031 | 0.000 |
| retainSp2019 | coreq | -0.144 | 0.053 | 0.007 | -0.069 | 0.026 | 0.007 |
| retainSp2019 | priorPerf | 0.202 | 0.027 | 0.000 | 0.202 | 0.028 | 0.000 |
| retainSp2019 | fg | -0.177 | 0.057 | 0.002 | -0.088 | 0.028 | 0.002 |
| retainSp2019 | urm | 0.149 | 0.072 | 0.040 | 0.074 | 0.036 | 0.042 |
| retainSp2019 | Female | 0.115 | 0.043 | 0.007 | 0.055 | 0.020 | 0.007 |
| retainSp2019 | coreqXZPurpRel.1 | -0.004 | 0.029 | 0.882 | -0.002 | 0.016 | 0.882 |
| retainSp2019 | fgXZPurpRel.1 | 0.006 | 0.038 | 0.879 | 0.004 | 0.028 | 0.879 |
| retainSp2019 | urmXZPurpRel.1 | -0.055 | 0.038 | 0.152 | -0.034 | 0.024 | 0.157 |
| retainSp2019 | femaleXZPurpRel.1 | -0.091 | 0.034 | 0.007 | -0.070 | 0.026 | 0.007 |
| retainSp2019 | ZPerFac.1 | 0.042 | 0.028 | 0.139 | 0.041 | 0.027 | 0.136 |
| retainSp2019 | coreq | -0.133 | 0.053 | 0.012 | -0.064 | 0.026 | 0.013 |
| retainSp2019 | priorPerf | 0.203 | 0.027 | 0.000 | 0.203 | 0.028 | 0.000 |
| retainSp2019 | fg | -0.174 | 0.057 | 0.002 | -0.086 | 0.028 | 0.002 |
| retainSp2019 | urm | 0.162 | 0.071 | 0.023 | 0.080 | 0.036 | 0.025 |
| retainSp2019 | Female | 0.120 | 0.042 | 0.004 | 0.057 | 0.020 | 0.004 |
| retainSp2019 | coreqXZPerFac.1 | 0.077 | 0.036 | 0.033 | 0.043 | 0.020 | 0.033 |
| retainSp2019 | fgXZPerFac.1 | -0.004 | 0.031 | 0.887 | -0.003 | 0.022 | 0.887 |
| retainSp2019 | urmXZPerFac.1 | 0.014 | 0.034 | 0.684 | 0.008 | 0.021 | 0.684 |
| retainSp2019 | femaleXZPerFac.1 | -0.085 | 0.055 | 0.126 | -0.062 | 0.040 | 0.124 |

**Figure 1.** *Mindset histograms by corequisite status.*

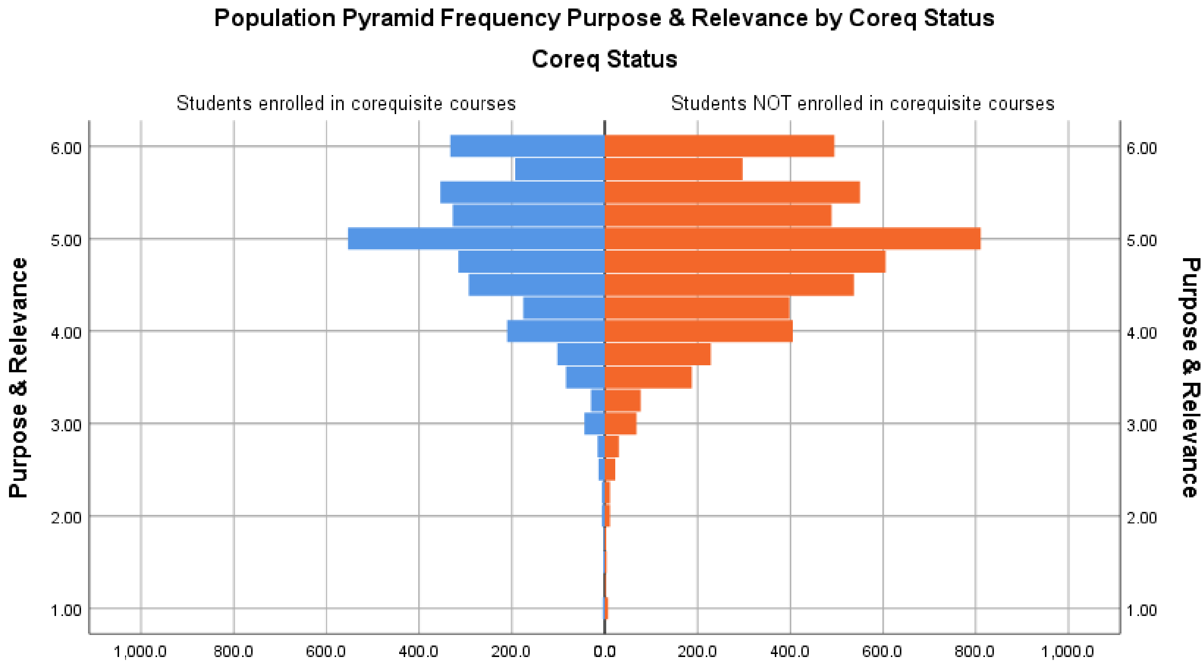
A) Student growth mindset



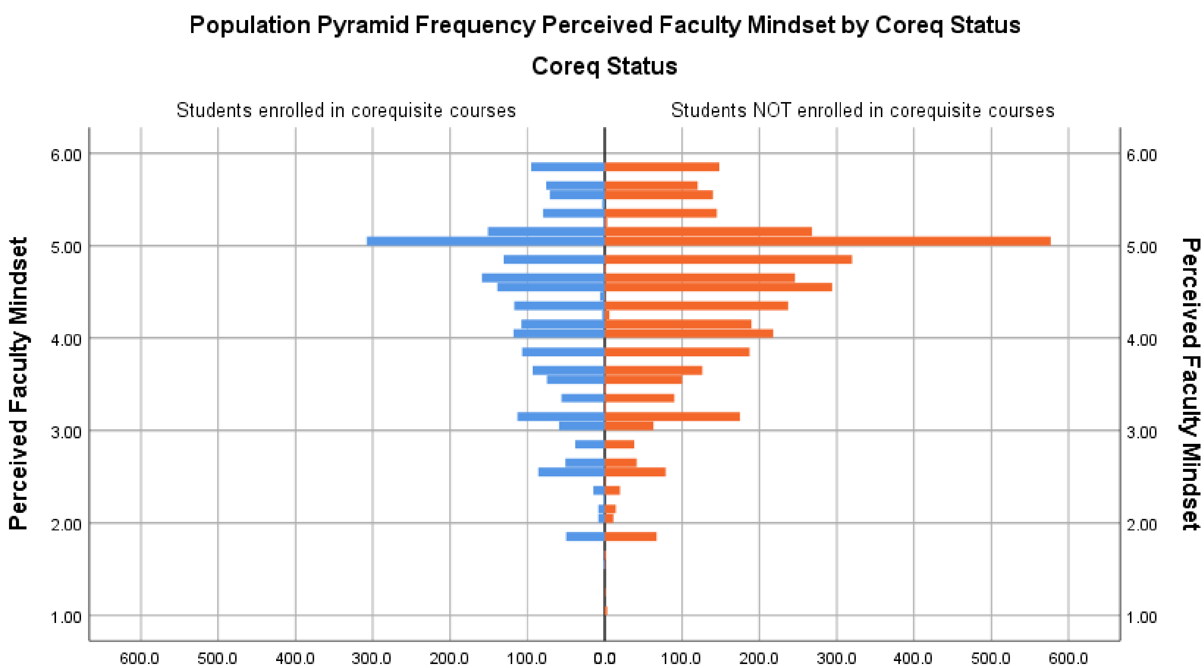

B) Belonging Uncertainty



C) Purpose & Relevance




D) Perceived Faculty Mindset



# End Notes

[1] Jaggars & Stacey, 2014
[2] Calcagno & Long, 2008
[3] Dadgar, 2012
[4] Martorell & McFarlin, 2011
[5] Xu, 2016
[6] Ran & Lin, 2019
[7] Cronin et al., 2021
[8] Tibbetts et al., 2016
[9] Bailey, Jeong, & Cho, 2010
[10] Hickey, Robinson, Fiorini, & Feng, 2020
[11] Autor, 2014
[12] Chen, 2016
[13] Darling-Hammond & Rothman, 2011
[14] Daugherty et al., 2018
[15] Scott-Clayton & Rodriguez, 2015
[16] Crisp & Delgado, 2014
[17] Horn & Nevill, 2006
[18] Goldrick-Rab, 2010
[19] Ran, 2020
[20] Logue et al., 2019
[21] Boatman, 2012
[22] Cho, Kopko, Jengins, & Jaggars, 2012
[23] Jenkins, Speroni, Belfield, Jaggars, & Edgecombe, 2010
[24] Logue et al., 2016
[25] Goudas, 2017
[26] Smith, 2015
[27] Wigfield & Eccles, 2000
[28] Lazowski & Hulleman, 2016
[29] Dweck, 2006
[30] Dweck, 1999
[31] Dweck & Leggett, 1988
[32] Dweck & Yeager, 2019
[33] Blackwell et al., 2007
[34] Claro & Loeb, 2019
[35] West et al., 2018
[36] Broda et al., 2018
[37] Yeager et al., 2016
[38] Hecht et al., 2021
[39] Hulleman & Harackiewicz, 2009
[40] Canning et al., 2018
[41] Perez et al., 2014
[42] Wang, Degol, & Ye, 2015
[43] Hulleman et al., 2017
[44] Walton & Cohen, 2007
[45] Pittman & Richmond, 2007
[46] Thomas, 2012
[47] Tinto, 1987
[48] Höhne & Zander, 2019
[49] Walton et al., 2015
[50] Muenks et al., 2020
[51] Canning et al., 2019
[52] Canning et al., 2021
[53] Harackiewicz & Priniski, 2018

[54] Rosenbaum, Deil-Amen, & Person, 2007
[55] Rosenbaum, Deil-Amen, & Person, 2007
[56] Williams et al., 2021
[57] SERN Compendium of Studies that Measure Learning Mindsets
[58] Bryk et al., 2015
[59] Kosovich, Hulleman, & Barron, 2017
[60] Walton & Brady, 2017
[61] Richardson et al., 2012
[62] Robbins et al., 2004
[63] Aronson, et al., 2002
[64] Harackiewicz et al., 2016
[65] Walton & Cohen, 2011
[66] Kosovich et al., 2015

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