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THE BENEFITS OF MATH COREQUISITE SUPPORT FOR ACADEMIC OUTCOMES FOR STUDENTS IN TEXAS

Abstract

An increasing body of robust evidence concludes that corequisite remediation in math and English is a cost-effective alternative to traditional developmental education, offering improved immediate course progression and potentially better persistence and completion. This is the first study to disentangle the impacts of the two main elements of the corequisite model: accelerated college course placement and concurrent academic support. Utilizing a fuzzy regression discontinuity design and variation in Texas colleges' implementation of math corequisites, the study shows that college-level math course placement without additional support increases passing rates by 22 percentage points. This effect rises to 36 percentage points with concurrent developmental support. These findings bolster a growing consensus around the benefits of accelerated developmental education and suggest that a corequisite approach may have significant advantages over removing developmental education requirements entirely.

Keywords: corequisite remediation, developmental education, acceleration, academic support, student success.

The Benefits of Math Corequisite Support for Academic Outcomes for Students in Texas

Colleges commonly assess newly enrolling students for math, reading and writing readiness using standardized assessments, and many of these students are deemed “not college ready.” Until recently, most colleges required these students to enroll in a series of semester-long developmental education (DE) courses that required tuition payments and were graded but offered students no college credit. Research demonstrated that these DE course sequences were acting as barriers to college success (Bailey et al., 2010; Community College Research Center, 2014), and states and colleges across the country are now scaling accelerated approaches to providing math, reading, and writing support that are focused on ensuring all college students enrolled sooner into college-level courses (Rutschow et al., 2019).

Corequisites have emerged as one of the most common approaches that states and colleges are adopting to accelerate students (Rutschow et al., 2019). Corequisites require college students to enroll directly into a college-level course that focuses on math, reading or writing while receiving simultaneous, aligned academic support in that same subject area. There are a range of different approaches to corequisites; for example, students may be enrolled in two back-to-back class sessions—one for the college course and one for the additional academic support—or students may be required to participate in mandatory weekly tutoring to receive the additional support (Daugherty et al., 2018; Meiselman & Schudde, 2022). Studies have consistently shown that corequisites can help to increase the likelihood that students will pass a first college course, while the evidence on persistence and completion is mixed (Logue et al., 2016; Logue et al., 2019; Meiselman & Schudde, 2022; Miller et al., 2021; Ran & Lin, 2019). As of 2021, 24 states allowed or required the use of corequisites, with some states like California and Texas passing legislation that called for corequisites as the primary approach to academic support for students who test below college-level (Education Commission of the States, 2021).

Given the growing use of corequisites, understanding the effectiveness of different approaches has considerable significance for policymakers and educators. Some recent research examines the effect of certain aspects of corequisite design (e.g., instructor, class size, type of support) (Bahr et al., 2022; Ryu et al., 2022). Yet a key question that remains unanswered is what the academic benefits are of the required academic support. The additional academic support requires time and tuition but do not confer college credit and require significant time and effort for colleges to deliver effectively. Thus, it is crucial to understand whether these academic supports improve student outcomes. If not, much of the benefits of corequisites documented in the literature might be achieved by placing students directly into the college course without requiring the additional support.

In this paper, we disentangle the benefits of acceleration (e.g. immediate college course placement) from the benefits of the corequisite academic support by comparing students in corequisites relative to both standalone DE and standalone college-level courses. As is common in the DE literature, our research design relies on a fuzzy regression discontinuity design (RDD) that compares students who score just above and below a cut score that is used to determine college readiness. Importantly, however, Texas colleges scaled corequisites at different times, resulting in differences across campuses in the degree to which they placed students identified as needing developmental education in standalone DE or into corequisites. We leverage this variation across colleges to augment the standard RDD approach so that we can distinguish the effect of the academic supports and course acceleration. Effectively, our approach compares the effects of placement into DE in colleges that mainly rely on corequisites to that in colleges that mainly use standalone DE to distinguish the effect of standalone DE and corequisites (relative to standalone college-level courses).

We find that for math, acceleration into college-level courses significantly increases the probability that students completed a college-level math course within one or two academic years, but the effect was significantly larger when acceleration was paired with a DE support in the form of a corequisite. Specifically, relative to placement in standalone DE, placement into a standalone college-level mathematics course increased the college-level math pass rates by 35 percentage points. This effect was 47 percentage points when the college-level math course was paired with a DE support in a corequisite model. The difference of 12 percentage points was both substantive and highly statistically significant.

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These results suggest that students who are accelerated into college-level math courses can benefit from additional hours of corequisite academic support, and states and institutions should be cautious about removing the supplemental academic support from math corequisites in favor of direct placement into college courses without the additional academic support. Further, because our analysis focused on students who tested at the higher end of the developmental education range, they may underestimate the benefits of academic support for students who test at lower levels on basic math concepts. With additional evidence on the value of the corequisite support, states and institutions can weigh these benefits against the costs (e.g., faculty time invested in building out the support, tuition paid by students) to identify how much to invest in corequisite initiatives.

Background

Prior Evidence on Developmental Education and Corequisites

Research indicates that corequisites can improve academic outcomes for students. An experimental study conducted at CUNY found that students who were randomized to a corequisite statistics course were 14 percentage points more likely to pass a first college math course and 8 percentage points more likely to complete college (Logue et al., 2019). An experimental study of Texas English corequisites found positive outcomes for passing a first college course and increased course accumulation, but no impacts on persistence or completion outcomes (Miller et al., 2021). Quasi-experimental papers that leverage the statewide scaling of corequisites in Tennessee and Texas find positive early college course completion outcomes but limited evidence of longer-term completion outcomes (Meiselman & Schudde, 2022; Ran and Lin, 2019).

The variation in how corequisites have been delivered has provided opportunities to build evidence on how design features are related to student outcomes. A paper examining math corequisites in Texas found that the factors associated with higher rates of academic success included larger class sizes for the college course, mixed-ability college courses, in-person courses, increased time in the academic support, having a lecture-based academic support, and having the same instructor for the college course and support (Ryu et al., 2022). In Colorado data, Bahr et al. (2022) found different results for math and English. In math, offering the support immediately after the college-level course and scheduling students as a cohort was related to success for corequisite students. In English, having the same instructor was the factor most closely related to success for corequisite students (Bahr et al., 2022). The subject matter of the college math course is also important; non-algebra math courses were driving most of the positive effects that they observed on short-term course outcomes from corequisites (Ran and Lin, 2019; Ryu et al., 2022).

Our paper tackles a fundamental question around the design of corequisites: *Does the corequisite academic support help to improve academic outcomes, or might students be better off enrolling directly into the college course without the support?* While prior studies of corequisites have focused on comparing corequisites to traditional DE as the counterfactual, no study has compared corequisites to standalone college courses. Evidence suggests that many students are being misplaced into DE, and if placed directly into the college-level course, and some students may have passed without any additional academic support (Scott-Clayton et al., 2014). Yet students typically must pay tuition for the additional instructional hours required for the corequisite support, and the additional academic support may crowd out the time that students have to enroll in other courses. This suggests that for at least some students, the value of direct enrollment in the college course may outweigh the value of the corequisite. Moreover, from the perspective of policymakers and practitioners, the DE support provided in the corequisite model is expensive and can be administratively challenging to implement, so it is important to assess the benefits relative to simply enrolling students in a standalone college level course without DE support.

Conceptual Framework

In order to think about the benefits and costs of corequisites, we rely on Scott-Clayton and Rodriguez's (2015) conceptual framework that described DE in terms of delay, diversion, and development. Traditional DE *delayed* student movement into college-ready course work by requiring one or more semesters of prerequisite basic skills coursework, while accelerated DE reforms were adopted under the theory that this delay is harmful to students, and it is better to place students immediately into college-level courses (Community College Research Center, 2014). Traditional DE *diverted* students into different sections of courses under the theory that tracking students could provide opportunities for support that better aligned with student needs (Scott-Clayton and Rodriguez, 2015), while accelerated DE reforms in Texas often eliminated this tracking and mixed students assessed at “college ready” levels with those assigned to corequisites (Daugherty et al., 2019; Park et al., 2022). Mixing students by ability might provide opportunities to leverage peer effects and may help to ensure that instructors maintain high standards for students across course sections. Corequisite models provide development differently; they often reduce the overall hours of developmental support, and they modify how academic support is provided to place a greater emphasis on aligned, “just in time” support, which may result in higher-quality opportunities for development relative to the traditional model where the academic support was provided as a separate pre-requisite course that students were required to take in a prior semester (Daugherty et al, 2018).

Under this conceptual framework, the question of whether students will benefit more from a corequisite or more from direct placement into a college-level course without support depends on whether the developmental benefits of those additional academic support hours in the corequisite outweigh the costs of delaying other credit-bearing coursework. While corequisites do require students to immediately enroll in the college-level course, students are also typically required to enroll in up to three hours of additional weekly academic support. This academic support typically requires tuition and time from the student but does not provide the student with college credits that contribute to a degree. Assuming that the student has a fixed number of hours available for college coursework, these academic support hours may delay the opportunity for students to enroll in another credit-bearing course. When students enroll directly into a college course without corequisite support, this “delay” associated with DE is eliminated, but students also lose access to the development that those additional academic support hours may have provided. Further, some corequisite models continue to track DE students and non-DE students into different college courses, so any remaining diversionary effects associated with DE disappear when moving from placing students into the college course directly as opposed to the corequisite.

We might anticipate that these tradeoffs between the developmental aspects of the corequisites and the possible delay and diversion differ for students who come in with different levels of preparation in math, reading and writing. Some students may require very little or no developmental support to succeed in the college course, and in this case any delay and diversion created by the requirement to participate in the academic support is costly. A study examining college placement and academic outcomes indicates that approximately as many as one-fifth of students assigned to DE were “underplaced” because they would have received a B if placed directly into a college math course (without academic support) (Scott-Clayton et al., 2014), and these students may not benefit much from required corequisite support. Other students who would not pass the college course without support may see large benefits from the corequisite academic support, and these benefits will outweigh any costs of diversion or delay. To address the varying support needs of students, institutions and states may need to consider targeting different levels of corequisite academic support to different students.

There also may be differences in the need for and value of corequisite support across math, reading and writing, and this shapes these tradeoffs between development, delay, and diversion. For example, the evidence on misplacement suggests that in some settings, a substantially larger portion of students who were assigned to reading and writing DE would have passed college English with a B or higher (Scott-Clayton et al., 2014). This suggests that more students may require development in math to pass the college-level course and the value of the additional hours of mandatory academic support in the corequisite may be greater. In addition, it may be that academic support is best delivered in different ways across different subjects. For example, the findings from Colorado and Texas suggest that different corequisite features are related to student success in English versus math, and that corequisites are more successful in certain subject areas (Bahr et al., 2022; Ryu et al., 2022). More investigation into corequisite instruction may be needed to understand whether this model of side-by-side "just in time" scaffolding works similarly across subjects, or whether different approaches across subject areas are needed.

Institutional Details

As the second-largest higher education system in the country (after California), Texas has 50 public two-year college systems and 37 public four-year colleges enrolling more than 1.5 million students as of 2017. The Texas Legislature passed the first DE reform legislation in 2011, requiring the Texas Higher Education Coordinating Board (THECB) to develop a statewide plan for DE that encouraged the adoption and scaling of evidence-based best practices to serve underprepared college students (THECB, 2012). Legislation required all public institutions to implement at least one accelerated strategy by 2015, and corequisites became one of the most common DE reform approaches adopted by Texas institutions. In June 2017, the Texas governor signed House Bill (HB) 2223, requiring institutions across the state to scale corequisite models. The law mandated a three-year progressive scale-up of participation in corequisites: 25% of student enrollments in DE in fall 2018 had to be in corequisites, and this increased to 50% in fall 2019 and 75% in fall 2020 (THECB, 2018). Later, the state scaled the policy to 100% of students through rulemaking (THECB, 2020).

While HB 2223 mandated scaling of corequisites according to specified benchmarks, colleges were free to move more quickly and there were no formal penalties in place for colleges that did not meet the benchmarks. This created significant variation across colleges in the extent to which they implemented corequisites during the years of our study, with some colleges moving quickly to near universal use of corequisites and others that moved more slowly and failed to meet the mandated benchmarks (Meiselman & Schudde, 2022). We argue that the timing of rolling out corequisites was largely idiosyncratic, and that it is particularly unlikely that students would choose colleges based on whether they were implementing corequisites or not. During this scale-up period between 2017 and 2020, a student at one local community college who scored within a particular range on the placement exam might be placed in a corequisite, while a similar student scoring in a similar range who enrolled at another college might go into a standalone DE course.

Importantly, this setup effectively creates two discontinuities: one that identifies the impact of corequisites relative to a standalone college level course (for colleges that were mostly implementing corequisites) and another that identifies the impact of a standalone DE course relative to a standalone college level course (at colleges that were mostly still using standalone DE). We leverage these discontinuities in an instrumental variables framework that allows us to separately identify the impact of enrolling in a corequisite, enrolling in a standalone college math course, and enrolling in a standalone DE math course.

Under state policy, corequisites must require students to be co-enrolled in a credit-bearing course and a DE support in the same subject area during the same semester, and passing the DE support cannot be a prerequisite requirement to participating in the college course. The learning objectives and the credit allowances for the college course were also set at the state level for all public colleges in Texas. Beyond these few state-level requirements, colleges had considerable flexibility over the design and implementation of the academic support provided within corequisites, including the structure, content, and pedagogy. These supports varied widely in terms of the number of credit hours required (i.e., 1 to 4 additional weekly instructional hours)[1], whether the instructor of the college course also provided that academic support, and whether the support was offered as additional course time or as a non-course-based option (e.g., tutoring) (Daugherty et al., 2018; Ryu et al., 2022; Mokher & Park-Gaghan, 2023).

Econometric Strategy

The purpose of this study is to estimate the effect of math corequisites on student outcomes. Several challenges make it difficult to isolate this effect. First, students are placed into corequisites based on a standardized test score, and test performance is

[1] In their analysis of math corequisite enrollments between fall 2018 and spring 2020, Ryu et al. (2022) found that the average number of instructional hours provided in the support was 2.3. The average size of a class for Texas math corequisites was 15 students for both the academic support and the college course. While the vast majority of the college courses were lecture-based (95%), one-quarter of the academic support models used non-lecture based approaches. Slightly fewer than half of corequisite enrollments were in sections where the same instructor taught both the course and the support. Approximately half of corequisite enrollments were in algebra, with the others split across statistics, quantitative reasoning, and business math. Among the faculty providing the corequisite support, 60% were white, 80% had graduate degrees, and 73% were employed full-time (Ryu et al., 2022).

likely to be highly correlated with outcomes regardless of one's course placement. To overcome this challenge, we use a regression discontinuity design (RDD). This approach relies on comparing students who score just above and just below the cut score used to determine whether a student can go directly into college-level courses. The intuition behind this strategy is that students scoring very close to the cut score are likely to be similar in terms of the determinants of outcomes other than their placement status. Numerous studies that evaluate the effect of developmental education on student outcomes have used this approach (Martorell and McFarlin, 2011; Daugherty, et al, 2021; Boatman and Long, 2017; Scott-Clayton and Rodriguez, 2015).

A second complication is that course enrollments sometimes deviate from placement decisions. The standard approach to addressing this problem is to use a fuzzy RDD, which uses the change in the probability of enrolling in a course type at the cut score as an instrumental variable for actual course enrollment. A distinctive challenge in this setting is that whether a student scores above the cut score affects not only placement into corequisites versus a standalone college-level course, but also placement into standalone developmental education (i.e., without a concurrent college-level course). This means that a standard fuzzy RDD cannot isolate the effect of corequisites relative to a standalone college-level course.

We overcome this challenge by using the fact that colleges differ in their use of corequisites and standalone developmental education for students that do not place directly into a college-level course. As seen in Figure 4, the proportion of developmental education students in corequisites varied widely across colleges during the early implementation phase of HB 2223, with some colleges almost exclusively using standalone developmental education and others using almost all corequisites. This means that scoring below the cut score is much more likely to lead to standalone developmental education in some colleges and corequisites in others. By comparing the effect of scoring below the cut score in colleges that predominantly use corequisites to that in colleges that mainly use standalone developmental education we can estimate the effect of standalone college-level courses to both standalone developmental education and corequisites.

More formally, we will estimate the following model via two-stage least squares regression:

$$Y_{ic} = b_0 + b_1*DE_i + b_2*Coreq_i + b_3*PctCoreq_c + BX_i + g(S) + e \qquad (1)$$

Where Y_{ic} is an outcome for student i at college c; DE_i and $Coreq_i$ are indicators that student i enrolled in a standalone DE or a corequisite math course in their first semester (the reference group being a standalone college-level math course); $PctCoreq_c$ is the percentage of FTIC DE students at college c who enrolled in a corequisite model; X_i is a vector of student-level covariates; g(S) is a flexible polynomial for student i's score on the first attempt of the mathematics placement exam; and e is an idiosyncratic error term. Note that both DE_i and $Coreq_i$ are endogenous variables, since students are often able to influence their initial course placement by retesting or advocating on their own behalf, even when there is a strict cutscore in place.

Since this model has two endogenous variables, we need at least two instrumental variables to estimate this equation. As in a standard fuzzy RDD, one instrumental variable is an indicator variable for scoring below the cutoff score. The second is the interaction between scoring below the cut score and the percentage of developmental education students who take a corequisite at the college attended by student i. This gives the following “first-stage” equations:

$$DE = a_0 + a_1{*}BelowCut + a_2{*}BelowCut{*}PctCoreq + c_3{*}PctCoreq + AX_i + g(S) + v \quad (2)$$

$$Coreq = c_0 + c_1{*}BelowCut + c_2{*}BelowCut{*}PctCoreq + c_3{*}PctCoreq + CX_i + g(S) + u \quad (3)$$

Where DE_i, $Coreq_i$, $PctCoreq_c$, X_i, and g(S) are defined as before; and BelowCut is an indicator that student i scored below the cutscore on the first attempt at the math placement exam. This approach requires that determinants of student outcomes other than course placement trend smoothly through the placement cut score. This is the standard continuity assumption needed for a valid RDD, and ensures that differences in student outcomes on either side of the passing cutoff identify the effect of being placed into a college-level course. Consistent with this assumption, we present evidence below that the distribution of test scores and “pre-determined” variables (e.g., student demographic characteristics) are not discontinuous at the cut score.

Beyond the standard RDD assumption, our instrumental variables approach further requires that any differences in the effect of a student's placement test outcome across colleges are due to different rates of corequisites across colleges. This rules out, for instance, that differences in the effect of course placement in colleges with high rates of corequisites are due to differences in the effectiveness of instructors across colleges. This is both a stronger assumption and harder to test than the standard RDD assumption. However, it is one that we must make to separately estimate b_1 and b_2.

Data and Sample

To implement the research design described in the prior section, we use data from the UT Dallas Education Research Center. This data includes administrative data from the Texas Higher Education Coordinating Board (THECB), which covers all higher education institutions in Texas. The THECB records contain detailed information on student courses, enrollment, and placement test scores.

Our sample consists of students who first entered college in a Texas community college in fall 2018 and who took the Texas Success Initiative Assessment (TSIA) college readiness assessment for the first time between February 1 and August 31, 2018. During this period, 53,197 such students took the placement assessment for the first time. The TSIA is a standardized test and readiness benchmarks are set by THECB. We use students' scores from their first time taking the assessment, to avoid any potential manipulation of the running variable due to students who may retake the test until achieving a passing score.

Since we are focused on mathematics developmental education, we further restrict the sample to students who took a math course in their first semester. Note that we do not find any evidence that taking a math course in the first semester is affected by scoring above or below the placement test cut score (see Figure 1; the estimated discontinuity is .02 with a standard error of .03). This is important because it suggests that restricting the sample to students who take a math course in their first semester will not generate any selection bias and invalidate the RDD design (we investigate the validity of the RDD more thoroughly in the next section). After imposing these restrictions, we have a final analytic sample of 35,353 students.

Using transcript-level information from community colleges, we can identify which courses students took, when they took them, and their course grades. We classify students based on their initial math course as either enrolled in standalone developmental education, a standalone college-level course, or a corequisite, which we define as being concurrently enrolled in a college-level math course and some form of developmental education (either course-based or non-course based developmental education). In our sample, 18,260 students are in standalone developmental education (52 percent), 6,946 are in a corequisite (20 percent), and 9,887 (28 percent) are in standalone college-level math.

We then follow students through spring 2020 and construct a variety of short- and medium-run indicators of student success. One is whether a student passed a college-level math course. Second, we examine whether persistence in college, defined as whether a student remained enrolled as of the end of a particular semester. Finally, we consider college credits earned, where we distinguish between developmental course credits (which do not count towards academic degrees) and college-level course credits. For each outcome, we examine them in each semester through spring 2020.

Table 1 provides summary statistics for our sample. The sample has large shares of racially minoritized students, economically disadvantaged students. More than 80 percent of students score below the college-level cut score in math, and 72 percent of students are in some form of developmental education (52 percent in standalone DE and 20 percent in a corequisite). Students scoring below the placement test score are more likely to be economically disadvantaged, older, belong to a racially minoritized group, and have lower test scores on all three sections of the placement test.

Overall, two-thirds of students took a college-level math course by spring 2019, and 71 percent by spring 2020. Passing rates are much lower, with only 46 percent passing a college-level math course by spring 2020. While 85 percent of students remained enrolled in spring 2019, only 56 percent enrolled in spring 2020, consistent with low degree completion rates among community college students (Bailey et al. 2015).

Results

Validity of Regression Discontinuity Assumptions

We begin by presenting results consistent with a valid RDD. First, we examine the distribution of placement test scores. In a valid RDD, one would expect the number of students to trend smoothly through the placement test cutoff, resulting in the distribution of placement test scores being continuous at the cutoff. Raw scores range from about 310 to 380; the cutoff for a passing score is 350. Figure 2 presents the distribution of centered scores. As seen in Figure 2, the test score distribution is continuous throughout the range of scores and follows a normal distribution. There is no visual evidence of manipulation of the forcing variable to shift students' scores toward passing at the cutoff.

A valid RDD also implies that observable correlates of student outcomes ought not exhibit discontinuities at the cut score. To evaluate whether the data support this implication, we estimated discontinuities in the baseline covariates listed in Table 2. Some of the estimated discontinuities for the race indicators (race unknown and two or more races) are statistically significant at the 5 percent level, but are very small in magnitude (1 percentage point). The estimate for economically disadvantaged is a bit larger (4 percentage points). Otherwise, the discontinuities are small and statistically insignificant. Notably, the reading and writing test scores trend smoothly through the cut score. Overall, the evidence is consistent with the lack of "endogenous sorting" around the cut score and support the validity of the RDD. We include these correlates in our models as covariates.

First Stage Results

Table 3 shows first-stage point estimates for discontinuities in standalone and corequisite developmental math enrollment using two different model specifications: Model 2 adds an interaction term between whether a student's first math TSIA score is above the readiness benchmark and the percentage of developmental math course takers in the student's college who enroll in a corequisite developmental course rather than a standalone developmental course (see Figure 4 for variation across colleges in percent enrolled in a corequisite developmental course). We report both models in the first stage results but use Model 2 in the second stage estimates to address the availability of two possible developmental course options.

As would be expected, there are sharp decreases at the cut score in the proportion of students enrolling in both (a) a standalone developmental math course and (b) a corequisite developmental math course in their first semester of college (Figure 3, panels [a] and [b]). Students who score above the readiness benchmark are significantly less likely to enroll in both corequisite (panel a) and standalone (panel b) developmental courses. In schools with higher percentages of developmental math students taking corequisite courses, there is a significantly lower likelihood of enrolling in corequisite developmental courses for students above the cut score. (In schools with lower percentages of developmental math students taking corequisite courses–and therefore higher percentages taking standalone developmental courses–there is a higher likelihood of taking corequisite courses above the cut score, although overall corequisite participation above the cut score is low.) The F-statistics are large for both first-stage outcomes, providing further support for strong discontinuities at the cut score.

Second Stage Results

Our second stage results show that students who enrolled in a corequisite model of developmental math (a college-level course plus a developmental corequisite) were significantly more likely to pass college math than students who enrolled in standalone college-level math in every semester. The difference was 7 percentage points in fall 2018, and 12,13, and 14 percentage points in spring 2019, fall 2019, and spring 2020, respectively (Table 4). Conversely, students who enrolled in a standalone developmental math course were significantly less likely to pass college math in every semester, although the disadvantage decreased from 40 percentage points in fall 2018 to 22 percentage points by spring 2020.

As expected, students who enrolled in both corequisite and standalone developmental math earned more developmental credits than students who enrolled in standalone college math their first semester. Students who started in corequisite math earned between 2.52 and 2.62 more developmental credits as of each semester, compared with students who started in standalone college-level math; students who started in standalone developmental math earned between 2.64 and 3.66 more developmental credits than students who started in standalone college-level math (Table 4).

Students who first enrolled in corequisite math initially earned about 2 fewer college-level credits than students who first enrolled in standalone college-level math (Table 4). This difference decreased somewhat over time and was statistically significant only in fall 2018 and spring 2019; by fall 2019, there was no significant difference between the two student groups in the number of college-level credits earned. Students who first enrolled in standalone developmental math earned even fewer college-level credits: the difference between these students and students who first enrolled in standalone college-level math was about 3.56 credits at the end of fall 2018 and increased to 4.73 credits in spring 2019 and 6.13 credits in fall 2019. The difference in spring 2020 was 5.47 credits but was not statistically significant.

We did not find any significant differences in persistence to the end of spring 2019, fall 2019, or spring 2020 between students who first enrolled in either corequisite or standalone developmental math and students who first enrolled in standalone college-level math.

Conclusion

While there is a large and growing body of evidence demonstrating that corequisite remediation dramatically improves short term course progression outcomes and may also improve persistence and completion, evidence on the factors responsible for these impacts is only beginning to emerge. This is the first study of which we are aware to separately estimate the impact of the two primary components of corequisites: acceleration into college level coursework, and concurrent and aligned developmental education support. Overall, our results suggest that the positive impact of corequisites on short run course progression outcomes are attributable both to acceleration and the developmental education support: relative to a standalone DE math course, enrolling in a standalone college-level math course increased the probability of passing a college-level math course within two academic years by 22 percentage points, while the corresponding impact of enrolling in a math corequisite was 36 percentage points. Consistent with much of the research on corequisites, we find no impact of enrolling in either a standalone college math or a math corequisite on persistence.

With respect to Scott-Clayton and Rodriguez's (2015) conceptual framework, which focused on delay, diversion, and development, these results are consistent with the notion that the developmental benefits of standalone DE are strongly outweighed by the detriments in terms of delay and diversion. The result is that students are better off being placed directly into a college level math course with or without support – a finding consistent with a growing research base. However, what is particularly novel about our study is the fact that we demonstrate that students are best off when placed into a corequisite model. This suggests that there are real benefits of the development driven by the concurrent and aligned support, and these benefits outweigh the detriments from delay and diversion associated with the need to take additional credits associated with that support.

For policymakers and practitioners, our findings buttress a growing evidence-based consensus that accelerated approaches to DE represent a significant improvement over traditional pre-requisite models. Recent evidence on the cost effectiveness of corequisites in Texas and Tennessee demonstrates that, while the corequisite model is costly to implement, it is also a solid investment when compared to the pre-requisite model (Cunha, et. al., 2023; Belfield, et. al., 2016). While our study demonstrates there are clear benefits to the corequisite model relative to placement in a standalone college-level course, it is also clear that corequisites are significantly more costly to implement effectively than simply doing away with DE and placing students directly into college level courses. Future research should compare the costs and benefits of corequisite remediation, relative to standalone college course placement.

Finally, while research has consistently demonstrated that corequisites improve short-term course progression outcomes, our results are consistent with the majority of studies that find that early success associated with the model does not translate to improvement in persistence and completion (Miller et. al., 2021; Miller and Martorell, 2022, Ran and Lin, 2022). More research is needed to ensure that students who benefit from corequisites or acceleration generally can continue to succeed once they progress through early college-level courses. Some researchers have suggested pairing accelerated approaches with other proven models such as math pathways and models, holistic advising and approaches that continue to support students throughout their time in college (Miller and Martorell, 2022).

Tables

Table 1. Summary Statistics

	Overall	Score below cutoff	Score above cutoff
Demographics	N=35,353	N=28,833	N=6,520
Male	0.44	0.41	0.53
White	0.28	0.26	0.34
Black	0.14	0.15	0.08
Asian	0.03	0.02	0.07
American Indian/Alaskan Native	0.00	0.00	0.00
Two or more races	0.03	0.03	0.03
Hispanic	0.50	0.51	0.45
Unknown race/ethnicity	0.01	0.01	0.01
International student	0.01	0.01	0.01
Age over 21	0.13	0.14	0.07
Economically disadvantaged	0.47	0.49	0.39
First math test score - centered	–12.43 (13.75)	–16.69 (11.16)	6.37 (6.38)
First reading test score - centered	–1.16 (12.63)	–2.62 (12.15)	6.73 (12.26)
First writing test score - centered	5.80 (11.19)	4.40 (10.74)	13.26 (10.55)
Math level fall 2018			
Standalone developmental	0.52	0.64	0.01
Corequisite developmental	0.20	0.24	0.02
Standalone college level	0.28	0.12	0.97
Outcomes			
Took first college math			
by spring 2019	0.63	0.54	1.00
by fall 2019	0.69	0.62	1.00
by spring 2020	0.71	0.65	1.00

Passed first college math			
by fall 2018	0.27	0.19	0.63
by spring 2019	0.36	0.29	0.68
by fall 2019	0.42	0.35	0.73
by spring 2020	0.46	0.39	0.74
Persistence			
to spring 2019	0.85	0.84	0.89
to fall 2019	0.68	0.65	0.78
to spring 2020	0.56	0.53	0.70
Developmental credits earned			
by fall 2018	3.19 (2.65)	3.83 (2.48)	0.38 (1.10)
by spring 2019	4.15 (3.70)	4.99 (3.55)	0.47 (1.39)
by fall 2019	4.51 (4.14)	5.41 (4.01)	0.51 (1.51)
by spring 2020	4.66 (4.35)	5.59 (4.23)	0.52 (1.57)
College level credits earned			
by fall 2018	8.42 (3.90)	7.68 (3.74)	11.66 (2.81)
by spring 2019	16.38 (7.75)	15.18 (7.48)	21.71 (6.62)
by fall 2019	24.17 (13.20)	22.40 (12.75)	32.00 (12.26)
by spring 2020	29.75 (17.78)	27.54 (17.21)	39.53 (16.95)

Note. Standard deviations for continuous variables in parentheses.

Table 2. Baseline Discontinuities of Observable Correlates of Student Outcomes

Variable	Coefficients (Standard Errors)
White	0.03
	(0.02)
Hispanic	–0.03
	(0.02)
Black	–0.01
	(0.01)
Asian	0.01
	(0.01)
Native American	0.00
	(0.00)
International	0.00
	(0.00)
Unknown Ethnicity	–0.01*
	(0.00)
Two or More Races	–0.01*
	(0.01)
Male	–0.02
	(0.02)
Age Over 21	-0.01
	(0.01)
Economically Disadvantaged	–0.04*
	(0.02)
First Reading Score	0.07
	(0.46)
First Writing Score	0.67

	(0.43)
N(overall)	35,353
N(left)	28,833
N(right)	6,520

Table 3. First Stage Results

	Dependent variable: Standalone DE		Dependent variable: Corequisite DE	
	Model 1	**Model 2**	**Model 1**	**Model 2**
Above cut score	–0.14***	–0.40***	–0.44***	–0.18***
	(0.04)	(0.04)	(0.04)	(0.04)
Above cut score * % corequisite participation		0.50***		–0.51***
		(0.06)		(0.09)
F-stat for joint hypothesis test		45.20		204.68

Note: Standard errors are in parentheses.

Table 4. Second Stage Results

	Fall 2018	Spring 2019	Fall 2019	Spring 2020
Passed College Math				
Coreq DE	0.07*	0.12***	0.13***	0.14***
	(0.03)	(0.03)	(0.03)	(0.03)
Standalone DE	–0.40***	–0.35***	–0.25***	–0.22**
	(0.07)	(0.07)	(0.07)	(0.07)
Persisted to End of Semester				
Coreq DE		–0.01	–0.01	0.01
		(0.02)	(0.03)	(0.04)
Standalone DE		0.00	–0.09	–0.01
		(0.05)	(0.06)	(0.06)
Developmental Credits Earned				
Coreq DE	2.53***	2.62***	2.52***	2.58***
	(0.30)	(0.33)	(0.34)	(0.35)
Standalone DE	2.64***	3.20**	3.52***	3.66***
	(0.75)	(0.92)	(0.97)	(0.99)
College Credits Earned				
Coreq DE	–1.91***	–2.03***	–1.85	–1.78
	(0.30)	(0.55)	(1.14)	(1.60)
Standalone DE	–3.56***	–4.73**	–6.13**	–5.47
	(0.96)	(1.40)	(2.21)	(2.96)

Note: Standard errors are in parentheses.

THE BENEFITS OF MATH COREQUISITE SUPPORT FOR ACADEMIC OUTCOMES FOR STUDENTS IN TEXAS

Figures

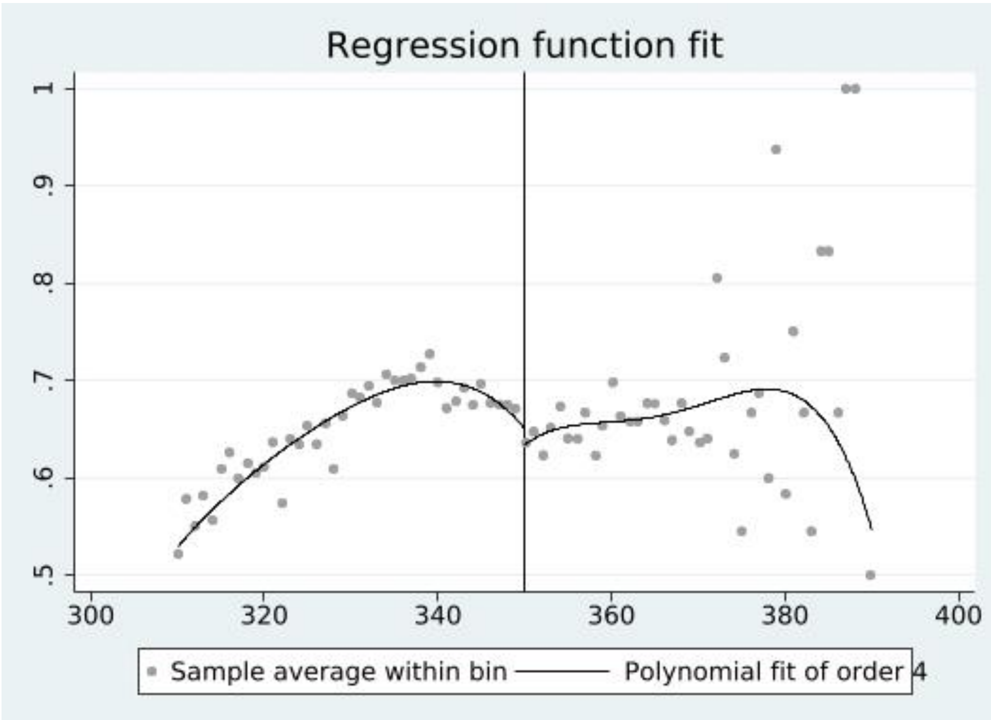


Figure 1. Proportion of students taking any math course in the first semester by first math TSIA score

THE BENEFITS OF MATH COREQUISITE SUPPORT FOR ACADEMIC OUTCOMES FOR STUDENTS IN TEXAS

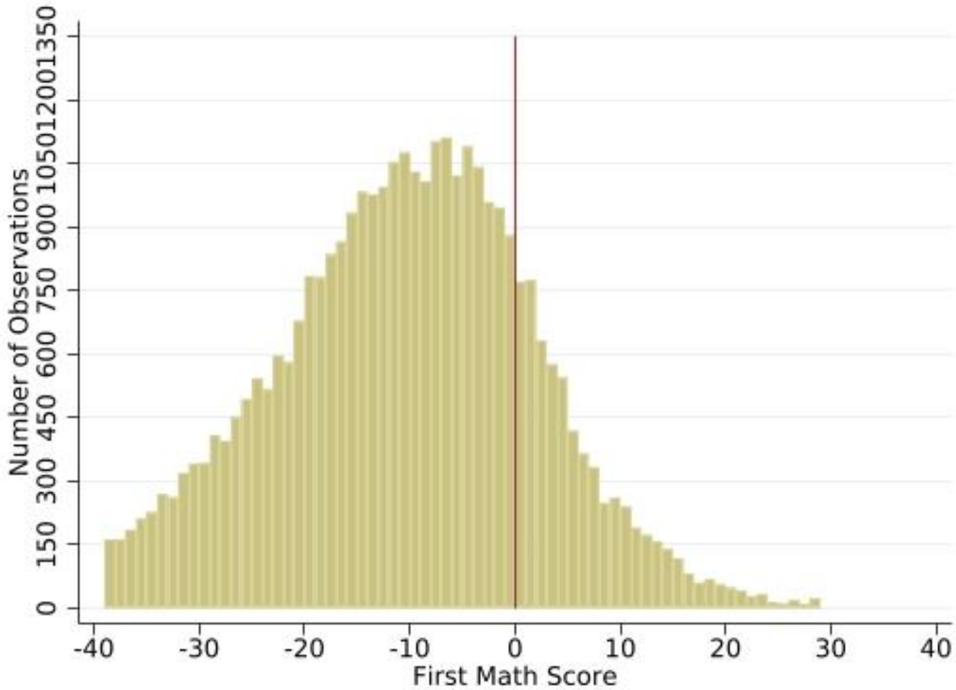
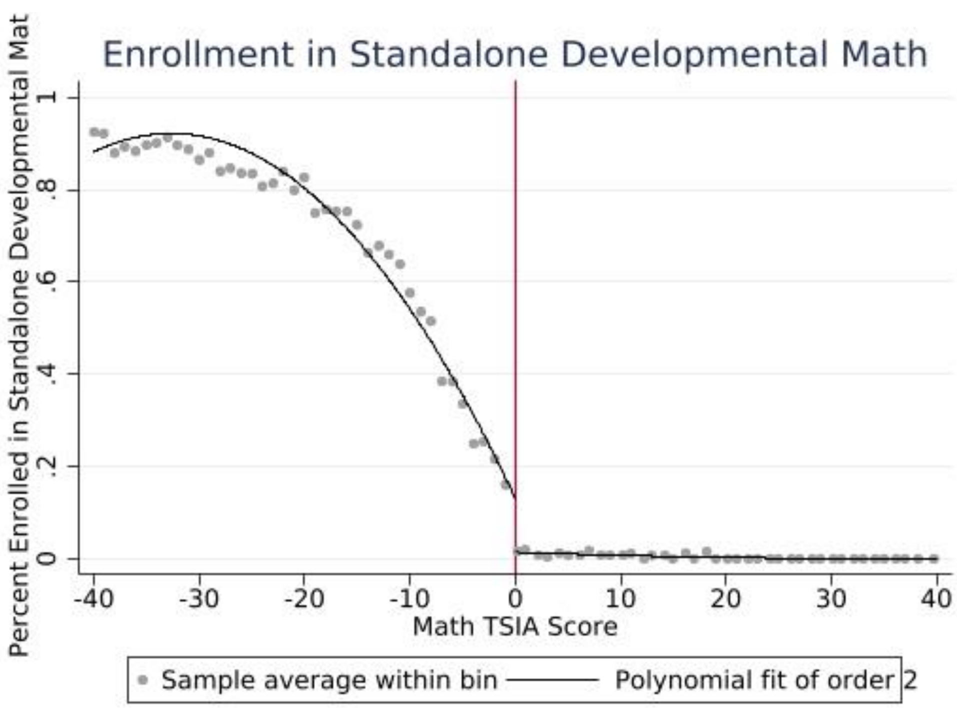
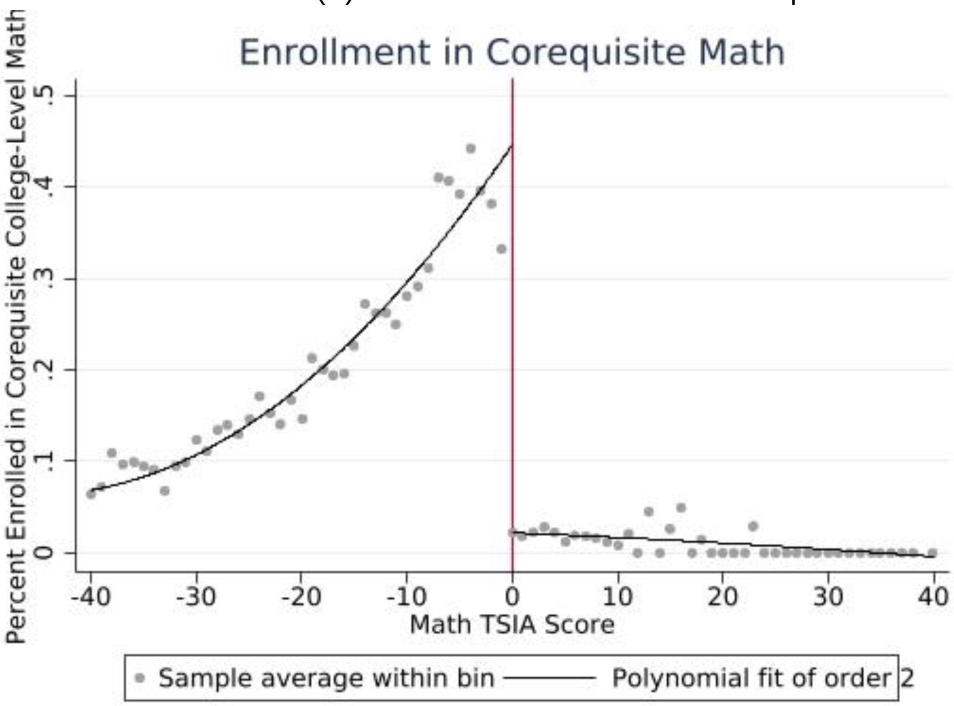


Figure 2. Distribution of the the running variable centered at the cut score



Panel (A) Enrollment in Standalone Developmental Math



Panel (B) Enrollment in Corequisite Developmental Math

Figure 3. First Stage Discontinuities in Standalone and Corequisite Developmental Math

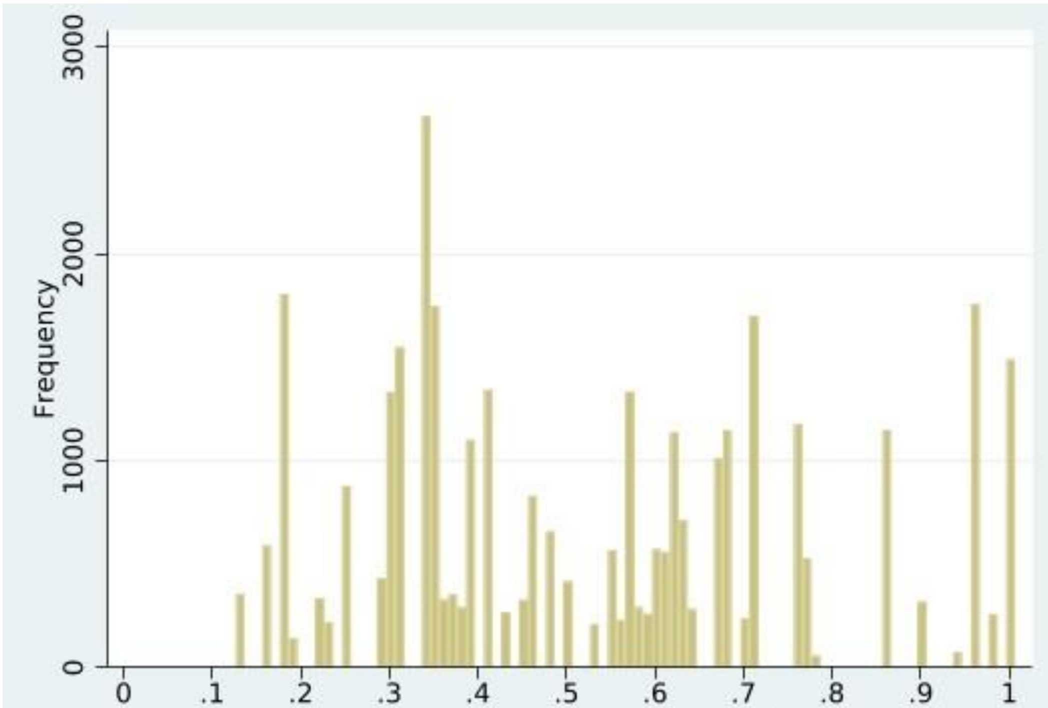


Figure 4: Proportion of developmental education students enrolled in corequisite models in fall 2018, by Texas college enrollments.

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