Texas Association of Community Colleges

# Course Repetition in College-level Mathematics Courses Among Community College Transfer Students

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Mathematics literacy is essential for many tasks in daily life and work. There is an expectation that all college students will develop mathematical reasoning during their college education. At the same time, math coursework serves as a hurdle to earning a credential for many students, potentially limiting students' ability to continue their participation in higher education, particularly for those who enter college underprepared for college-level math courses and instead must initially enroll in developmental education (dev-ed) (e.g., Bailey et al., 2010). Among community college students who hope to transfer to a baccalaureate-granting institution, taking the "right" math course that aligns with their intended program of study is vital to help them make progress toward their degree and avoid inefficient course-taking patterns. In this study, I will examine the relationship between student college outcomes (cumulative grade point average (GPA), bachelor's degree attainment within six-years, time to a bachelor's degree and accumulated excess credits) and course redundancy (hereafter *repetition*), determining math course-taking patterns among students who transferred from community colleges to public universities in Texas.

Although U.S. higher education institutions traditionally required all students to take college algebra to acquire necessary foundational skills, recently, they have begun to diversify their introductory (gateway) mathematics courses beyond the "college-algebra-for-all" approach. Recent reform efforts such as the Dana Center Mathematics Pathways and Carnegie Math Pathways encourage students to take an introductory (gateway) college-level mathematics course that fits their needs and majors. While college algebra might still be a required course for STEM majors, non-STEM students might be better served by a math course designed to serve their needs of the studies, such as statistics or quantitative reasoning. More community colleges are making multiple math pathways available to students (Schudde & Meiselman, 2019) and working to create guided pathways toward desired degrees (Jenkins & Pellegrino, 2019). Despite efforts to improve the flexibility of gateway math requirements and to streamline students' pathways toward a bachelor's degree, we have little information about course repetition in mathematics among community college students who transition to bachelor's-degree-granting institutions.

This study will analyze how course repetition patterns among community college transfer students in Texas predict student college outcomes (cumulative GPA, bachelor's degree attainment, time to degree, and excess credits). Using data from the Texas Educational Research Center, I leverage longitudinal statewide administrative records for the 2011-2012 and 2012-2013 community college entrants and track students' academic progress over six years.

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Please visit https://tacc.org/tsc for companion resources and to learn more about the fellowship.

## Why Mathematics Course-taking and Repetition Matter for Student Success

Although many student academic decisions can influence a student's overall success in higher education, a wealth of research has suggested that mathematics course taking strongly affects whether a student successfully persists at their institution and graduates with their degree (Adelman, 2005; Bahr et al., 2017; Calcagno et al., 2007). A handful of studies focus on course-taking patterns in a specific sequence at community colleges (e.g., developmental mathematics sequence by Bahr, 2009; college-level mathematics sequence by Bahr et al., 2017; the English as a Second Language (ESL) sequence by Park, 2019). Even though recent studies examine the course repetition/redundancy at community colleges, they focus on the course redundancy due to the misalignment of math course-taking requirement between high school and college. (Melguizo & Ngo, 2020; Ngo, 2020; Ngo & Velasquez, 2019; Park, Ngo & Melguizo, in press). In this study, I will provide the course repetition patterns among community college transfer students across multiple sectors (community colleges and universities) in college-level mathematics sequences.

Specific to empirical studies, Adelman (2005) conducted one of the earliest studies utilizing the milestone approach to examine transfer and associate degree attainment as the two successful outcomes for community college students. Credits in college-level mathematics in the first year were positive predictors of transferring to a four-year institution and of terminal associate degree attainment. Also, earning more college-level math credits at any time throughout the study was found to lead to an increase in the likelihood of earning a bachelor's degree (Adelman, 2005). Similarly, Calcagno et al. (2007) analyzed the transcript data of a cohort of first-time community college students in Florida. Applying event history modeling, they examined the probability of earning a community college credential in any given term for students who had previously enrolled in a remedial math course. For these students, taking and passing the first college-level math course were much more likely to graduate in any given semester, an effect that was strong for all students, but especially for those under age 25. Researchers have also examined the specific timing of completion of college-level math within plans of study (Calcagno et al., 2007; Zhang, 2019). For example, Zhang (2019) found that transfer students who took at least a college-level mathematics course in their first semester at a four-year institution were more likely to earn a STEM bachelor's degree than a non-STEM bachelor's degree.

Beyond examinations of transcripts, recent studies have explored redundancy, also known as misalignment, between high school and college mathematics courses at community colleges (Melguizo & Ngo, 2020; Ngo, 2020; Ngo & Velasquez, 2019; Park et al., in press). Even though high school graduates are college-ready in mathematics using different indicators high school GPA, high school mathematics courses, and standardized math test scores, they may still require taking remedial mathematics courses (Melguizo & Ngo, 2020). Community college students cannot escape math traps, which indicates students who are placed in mathematic classes that they took the same or lower-level courses at high school (Ngo & Velasquez, 2019). The math misalignment might lead to a decrease in pursuing STEM pathways among STEM-aspiring students (Park et al., in press). Students from lower socio-economic backgrounds, female and Black students, might experience more misalignment and course redundancy (Ngo, 2020; Ngo & Velasquez, 2019).

However, those studies did not investigate college-level mathematics course redundancy among community college students.

A handful of studies focus on course-taking patterns in a specific sequence at community colleges (e.g., developmental mathematics sequence by Bahr, 2009; college-level mathematics sequence by Bahr et al., 2017; the English as a Second Language (ESL) sequence by Park, 2019). For instance, one study found that a majority of students placed in remedial math course sequence could not successfully reach the college-level math courses (Bahr, 2008). In particular, students need to finish mathematics courses in a specific sequence to satisfy their course-taking and degree requirements. For example, the majority of STEM majors require students to take at least Calculus-I. Students need to finish courses in the college Algebra-calculus-I sequence (college algebra, trigonometry, pre-calculus, calculus) (Bahr et al., 2017). Extending this work, Bahr et al. (2017) used transcript data to investigate student progress towards college-level mathematics curriculum. However, those studies did not specifically examine the redundancy or repetition of mathematics courses at community colleges.

In this study, I provide course repetition of community college transfer students' pathways through the statewide mathematics curriculum in Texas. Utilizing a common core numbering system in Texas, I track student course-taking patterns across community colleges and universities. First, I capture what percentage of students repeat the same or lower-level college-level mathematics courses even though they successfully earned a credit from those courses in a sequence. Second, I also discuss where (what sectors) students repeat the math courses. Within the same sector (community college or university), I also explore the repetition patterns across multiple institutions and within the same institution. Third, I compare student college outcomes (cumulative GPA, bachelor's degree attainment, time to degree, and excess credits) by math repetition patterns (ever-course repeaters versus never-course repeaters). The study's findings provide an empirical foundation for policy and practice to advance our understanding of course redundancy in mathematics curriculum across different sectors and how course repetitions related to student outcomes.

## Types of Course Repetition

In this paper, I describe two types of course repetition: 1) *horizontal repetition*: taking additional course(s) at the introductory (gateway) college-level as a required course already taken; 2) *vertical repetition*: taking one or more additional college-level courses at the same or a lower level than a course previously earned in a specific sequence. As the student passes a college-level course, in both types of course repetitions, the student accrues additional, potentially extraneous, credits.

Figures 1 and 2 illustrate that students can repeat math courses either by taking more than one course at the same level (horizontal repetition) or repeating the same course over again (vertical repetition, which can include starting earlier in a given sequence).

***Figure 1. Horizontal Course Repetitions in Mathematics***

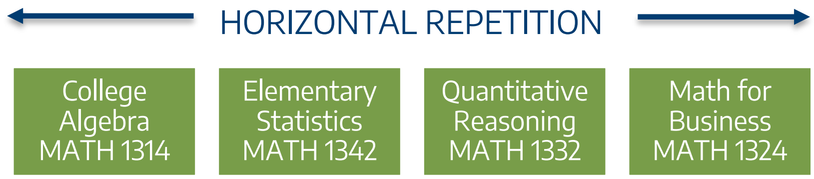
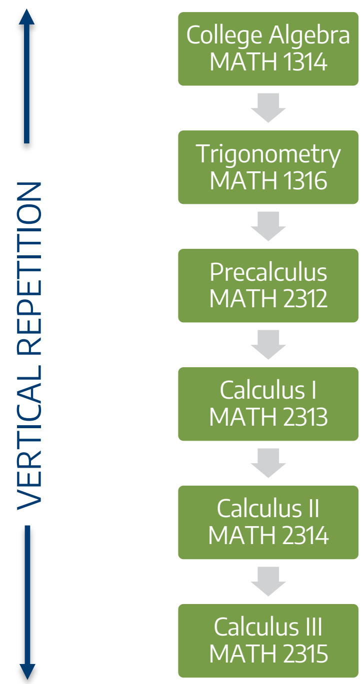



***Figure 2. Vertical Course Repetitions in Mathematics***




I capture horizontal repetition primarily as patterns where students complete an introductory college-level math course (e.g., college algebra, math for business, quantitative reasoning, or elementary statistics) with a passing grade and then taking another different introductory college-level math course. For instance, horizontal repetition occurs when a community college student takes college algebra in the first semester and takes quantitative reasoning in the second semester. Vertical repetition—retaking the same or a lower college-level math course within a prescribed sequence—occurs when a student retakes college algebra or trigonometry after passing trigonometry.

Course repetitions can occur when students enrolled at a community college or/and after transfer to a four-year university. For example, a student who successfully passed a Math for Business course (MATH 1324) and a college algebra course (MATH 1314) at a community college before transferring to a four-year institution would be classified as a horizontal repeater at the community college level. On the other hand, if the same student instead took college algebra (MATH 1314) at the four-year institution after the transfer, the student and their credits would be classified as a horizontal repetition at the university level. Overall, I identify four different types of course repetition patterns. Table 1 shows an example for each type of course repetitions: vertical repetition at the community-college level (Type 1), and vertical repetition at the university level (Type 2), horizontal repetition at the community-college level (Type 3), horizontal repetition at the university level (Type 4).

***Table 1. Four types of course repetitions***

| | | Community College | University |
|---|---|---|---|
| Vertical Repetition | Type 1 | Passed college algebra and retook college algebra | - |
| | Type 2 | Passed college algebra | Retook college algebra |
| Horizontal Repetition | Type 3 | Passed college algebra and then took quantitative reasoning | - |
| | Type 4 | Passed college algebra | Took quantitative reasoning |

I also capture a combined definition of the four types of repetition to assess whether students *ever-repeated* (refers to students who repeated a math course, either horizontally or vertically, at least once) or *never-repeated* (refers to students who never repeated a math course). Ever-vertical repeaters refer to the students who vertically repeat at least one course at a community college or/and a university. In other words, students who experience either Type 1 or Type 2 course repetition are identified as an ever-vertical repeater. On the other hand, never-vertical repeaters refer to students who never vertically repeat a math course at neither a community nor a university. The same logic can be applied to ever- and never-horizontal repeaters.

## Research Questions

In this study, I am guided by the following research questions:

1. To what extent do community college transfer students experience horizontal and vertical math course repetition?
    i. To what extent do horizontal and vertical course repetitions occur at a community college (before transferring) and a university (after transferring)?
    ii. For course repetitions prior to transfer, to what extent do horizontal and vertical course repetitions occur within a single institution or across multiple institutions?
2. Do horizontal and vertical course repetitions vary by students' characteristics (race, age, and gender)?

3. Do horizontal and vertical course repetitions vary by students' college experiences (FAFSA filers status, Pell-grant recipients' status, enrollment status, developmental, core, and field of study credits)?
4. Do vertical and horizontal course repetitions vary by college outcomes of students (cumulative GPA, earning a bachelor's degree, graduation delay (time to a bachelor's degree), and excess credits)?
5. How do vertical and horizontal course repetitions predict college outcomes of transfer students (cumulative GPA, earning a bachelor's degree, graduation delay (time to a bachelor's degree), and excess credits)?

**Data and Sample**

I used data from the Texas Higher Education Coordinating Board obtained from the Texas Education Research Center's (ERC). The sample for this study included first-time community college starters in 2011-2012 and 2012-2013 academic years in Texas who transferred to a four-year institution within six years of their community college enrollment. Analytical samples differ for vertical and horizontal repetition analyses. The analytical sample for horizontal repetition analysis includes students who took and passed at least one of the four introductory college-level courses (college algebra, elementary statistics, quantitative reasoning, and business for math) at a community college. However, the vertical repetition sample analysis includes all students who took and passed any college-level course at a community college. In other words, those analytical samples indicate total students eligible for specific repetitions. From those analytical samples, I categorize students into two distinct categories: ever- and never-repeaters. The final analytic sample for vertical repetition captured 36,079 community college entrants who passed at least one college-level mathematics course at a community college. In contrast, the analytical sample for horizontal repetition captured 33,205 transfer students who passed at least an introductory math course at a community college.

**Identifying First College-level Math Courses and Creating Repetition Measures**

To examine college-level mathematics course repetitions among community college transfer students, I focused on identifying and matching math courses across public community colleges and four-year universities in Texas. The Texas Common Core Numbering System (TCCNS) provides the lists of college-level mathematics courses with their prefixes and numbers for both public two-year and four-year colleges (e.g., MATH 1314 for college algebra). As TCCNS lists do not include all university math courses, I used the Texas Transfer Inventory Guide obtained from the Dana Center, which shows math courses aligned across all two-year and four-year public institutions in Texas (Dana Center, 2019). I added the Dana Center's transfer inventory list to the list of college-level math courses I obtained from TCCNS and matched those math courses' prefixes and numbers across institutions. Then, I prepared a spreadsheet that included all math courses' prefixes and numbers for each community college and public four-year institution in Texas.

I merged the resulting lists of math courses across the community colleges and universities in Texas with the student-level transcript data from the ERC. I created a flag for each transfer student's math courses grouped into 12 types of college-level math categories (please see Figure 1). Then, I identified students' each college-level mathematics course. All community college courses were assigned to each of the 12 college-level math categories. For each semester in which the student was enrolled, I identified the community college transfer student's math courses within the 12 college-level math categories at both community colleges and universities.

I flagged the semesters of college-level mathematics courses that students took and passed (D or above) for the first time at a community college. If students attempted the same or a lower level course at a community college or university, I marked those courses as course repetition patterns. For example, a community college transfer student took and passed Math for Teachers-I (MATH 1350) in the first semester at a community college and then attempted the prerequisite course college algebra (MATH 1314) in the second semester at a community college. This course-taking pattern was coded as a vertical repetition at a community college. Additionally, I marked this student as an ever-vertical repeater in the analysis.

**Analytical Strategy**

I fitted a series of stepwise OLS[1] (ordinary least square) regression models, entering groups of variables sequentially into the models, to determine how course repetition patterns (ever-vertical and ever-horizontal repeaters) predict student outcomes (cumulative GPA, bachelor's degree attainment within six-years, time to bachelor's degree completion and accumulated excess credits). I ran all models after controlling for the same set of demographic and college experience measures. While cumulative GPA and bachelor's degree attainment models included all community college transfer students, time to bachelor's degree and excess credits models included only students who earned a bachelor's degree.

The models included several variables I expected to influence student outcomes, including demographic characteristics, enrollment patterns, and achievement measures. I added various demographic criteria, such as race, gender, age, and financial aid receipt, associated with community college persistence and transfer (Bailey, Jenkins, & Leinbach, 2005; Schudde, 2019). I could not control for family income because doing so would have drastically reduced the final analytic sample). Still, I included a measure of ever having received the Pell Grant and an indicator for whether students applied for financial aid. Enrollment patterns, such as stopping out (breaks in college followed by re-enrollment) or attending part-time, have been linked to persistence and degree attainment (Bailey, Jaggars, & Jenkins, 2015; Fike & Fike, 2008; Park, 2012). To capture student enrollment patterns, I created measures of part-time, full-time (where students are the full time when for each semester enrolled, they took at least 12 credits) or mixed enrollment and number of stop-outs (how many times students stopped enrollment and then re-enrolled, other than taking off summer terms). In the final model, I was also able to include other academic measures likely to predict bachelor's degree attainment, such as cumulative GPA across all college credits and whether students earned an associate degree (Belfield, 2013). Also, I included students' broad major fields at a community college before transferring to a university because student

[1] I ran logistic regression for bachelor's degree attainment as the bachelor's degree attainment is binary. I found similar results. As OLS model provides easy interpretation, I preferred to report OLS results.

course repetition patterns vary by their pre-transfer majors. Finally, anticipating that students who switched majors after transfer might require additional credits to earn a bachelor's degree (Bailey et al. 2016), I included a dichotomous measure of whether students had a different broad Classification of Instructional Programs (CIP) code (the first two digits) during their semester directly before transfer and during their final semester at the university.

In the first model, I included course repetition indicators. For Model 2, I added background variables for race/ethnicity, gender, international student status, age, and financial aid indicators. In Model 3, I added measures capturing students' enrollment patterns, including enrollment intensity, stop-out counts, associate degree status, whether students switched majors after the transfer, and broad student majors. Finally, Model 4[2] included additional academic measures, which are developmental math credits earned at a community college and cumulative GPA[3].

## Findings

In the following sections, I present the descriptive and inferential findings from analyses. First, I discuss the frequency of mathematics course repetitions among community college transfer students. Second, I describe the ever- and never- horizontal and vertical course repeaters in terms of age, gender, and race/ethnicity. Third, I discuss ever- and never- horizontal and vertical course repeaters by their college experiences, such as enrollment status and financial aid status. Fourth, I discuss the regression results that examine the relationship course-repeaters and student outcomes.

### How typical is math course repetition among community college transfer students? Where does the course repetition occur?

I will discuss both horizontal and vertical course repetition patterns. While horizontal course repetition refers to course repetition occurring among introductory college-level courses (college algebra, math for business, quantitative reasoning, and elementary statistics), vertical repetition patterns refer to course repetitions that occur in a specific sequence.

#### *Horizontal Repetition and Vertical Repetition*

Table 2 shows the number of and percentage of ever-vertical and ever-horizontal repeaters and where those repetitions occurred. Two-fifth of students (40.6%, n=13,489) took additional introductory college-level math courses after passing an introductory college-level course (i.e., they took more than one gateway math course). As table 2 shows, transfer students are more likely to repeat those courses at community college (29.1%) compared to at university (14.1%). I further analyzed the patterns of course repetition before transfer as to whether the repetitions occurred within the same community college or a different community college. Findings revealed that 87% of the horizontal course repetitions before the transfer occurred within a single institution.

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[2] To save space, I only discuss results from the final Model-4s, which include course repetition indicators and all covariates for each outcome variable (Please see the appendices for stepwise tables).

[3] Cumulative GPA was used in the bachelor's degree attainment, time to degree and excess credits models.

As shown in Table 2, 17.2% of transfer students retook the same level or a lower-level course within the specific sequence. While the vertical repetition rate was 11.2% at the community college level, the same percentage was 7.7% at the university level. Similar to horizontal repetition, vertical repetition before transfer also occurred more frequently within a single community college (87.6%).

***Table 2. Horizontal repetition by students' first college-level math course and where they repeated (community college versus university)***

| | **Ever-horizontal Repeaters** | | **Ever-vertical Repeaters** | |
|---|---|---|---|---|
| | N | % | N | % |
| **Ever-Repeaters** | 13489 | 40.62 | 6394 | 17.22 |
| The institution where repetition occurred | | | | |
| University | 4691 | 14.13 | 2760 | 7.65 |
| Community College | 9647 | 29.05 | 4050 | 11.23 |
| Same community college | 8421 | 87.29 | 3550 | 87.65 |
| Different community college | 1226 | 12.71 | 500 | 12.35 |
| **Total Sample (N)** | **33,205** | | **36,079** | |

*Notes:* N (horizontal repetition) = 33,205- total students eligible for horizontal repetition (passed an intro math course); N (vertical repetition) =36,079- total students eligible for vertical repetition. The total sample (N) column shows the total number of community college transfer students in a specific type of eligible course repetition sample (either horizontal repetition or vertical repetition sample). Because the definitions of horizontal and vertical repetition include different subsets of college math enrollees, the total sample size differs across the two subgroups: the horizontal repetition sample (n=33,205) includes only those who take at least one of college algebra, math for business, quantitative reasoning and elementary statistics courses (as Figure 1 shows), the vertical repetition sample (n=36,079) includes transfer students who take any college-level math courses. The table presents course repetition for three groups of students: 1) ever-repeaters in the first row who ever experienced horizontal and vertical repetition at a community college or/and a university, 2) those who experienced the course repetitions at a university, and 3) those that experienced the course repetitions at a community college. Within those who experienced course repetitions at a community college, the table shows whether those course repetitions occurred within the same community college or in a different community college. Within each of those groups, the first column shows the number of horizontal and vertical repeaters ("N") and followed by the percentage of horizontal and vertical repeaters ("%") in that subgroup out of all eligible horizontal and vertical samples.

***Table 3. Community College Transfer Students' Background Characteristics and College Experiences by Type of Course Repetition (Vertical and Horizontal Repetition)***

| | Horizontal Repetition Sample | | | | Vertical Repetition Sample | | | |
|---|---|---|---|---|---|---|---|---|
| | Ever-horizontal repeaters | | Never-horizontal repeaters | | Ever-vertical repeaters | | Never-vertical repeaters | |
| | (N) | (% or Mean) | (N) | (% or Mean) | (N) | (% or Mean) | (N) | (% or Mean) |
| Total | 13489 | 40.6% | 19,716 | 59.4% | 6,394 | 17.2% | 29,685 | 82.8% |
| Race | | | | | | | | |
| White | 5,109 | 40.7% | 7,441 | 59.3% | 2,268 | 16.4% | 11,569 | 83.6% |
| Black | 1,198 | 42.0% | 1,652 | 58.0% | 556 | 18.3% | 2,477 | 81.7% |
| Asian | 992 | 53.0% | 878 | 47.0% | 466 | 20.2% | 1,841 | 79.8% |
| Hispanic | 5,459 | 38.1% | 8,872 | 61.9% | 2,791 | 18.5% | 12,338 | 81.5% |
| Other | 39 | 39.8% | 59 | 60.2% | 19 | 17.6% | 89 | 82.4% |
| Two or More | 692 | 45.9% | 814 | 54.1% | 294 | 17.7% | 1,371 | 82.3% |
| International Student | 91 | 35.8% | 163 | 64.2% | 62 | 19.9% | 249 | 80.1% |
| Gender | | | | | | | | |
| Female | 8,053 | 42.1% | 11,067 | 57.9% | 3,162 | 15.7% | 16,952 | 84.3% |
| Male | 5,436 | 38.6% | 8,649 | 61.4% | 3,232 | 20.2% | 12,733 | 79.8% |
| Age | 13,489 | 19.1 | 19,716 | 19.7 | 6,394 | 18.7 | 29,685 | 19.5 |
| FAFSA Filing Status | | | | | | | | |
| FAFSA Filers | 9,977 | 41.4% | 14,148 | 58.6% | 4,839 | 18.5% | 21,267 | 81.5% |
| Non-FAFSA Filers | 3,512 | 38.7% | 5,568 | 61.3% | 1,555 | 15.6% | 8,418 | 84.4% |
| Pell-Grant Recipient Status | | | | | | | | |
| Pell-Grant Recipients | 6,799 | 40.4% | 10,046 | 59.6% | 3,291 | 18.3% | 14,671 | 81.7% |
| Non-Pell Grant Recipients | 6,690 | 40.9% | 9,670 | 59.1% | 3,103 | 17.1% | 15,014 | 82.9% |
| Major switcher status | | | | | | | | |
| Major switcher | 4,433 | 44.1% | 5,616 | 55.9% | 2,197 | 20.0% | 8,801 | 80.0% |
| Non-major switcher | 9,056 | 39.1% | 14,100 | 60.9% | 4,197 | 16.7% | 20,884 | 83.3% |
| Enrollment Status | | | | | | | | |
| Part-time | 402 | 33.5% | 797 | 66.5% | 191 | 14.4% | 1,137 | 85.6% |
| Full-time | 632 | 34.7% | 1,188 | 65.3% | 268 | 13.1% | 1,774 | 86.9% |
| Mixed enrollment | 12,455 | 41.3% | 17,731 | 58.7% | 5,935 | 18.1% | 26,774 | 81.9% |
| Dual Credit Enrollment | | | | | | | | |
| Dual credit taker | 4,181 | 40.0% | 6,266 | 60.0% | 1,960 | 16.5% | 9,908 | 83.5% |
| Non-dual credit | 9,308 | 40.9% | 13,450 | 59.1% | 4,434 | 18.3% | 19,777 | 81.7% |
| Cumulative Dev-ed math credits | 13,489 | 2.07 | 19,716 | 2.7 | 6,394 | 2.1 | 29,685 | 2.3 |
| Cumulative Field of Study credits | 13,489 | 2.92 | 19,716 | 2.7 | 6,394 | 3.6 | 29,685 | 2.9 |
| Cumulative Core curriculum credits | 13,489 | 46.79 | 19,716 | 42.8 | 6,394 | 48.3 | 29,685 | 43.00 |

*Notes*. The table shows the characteristics of students experiencing different types of math course repetition. It presents the number of community college transfer students (N) within different repetition types and the corresponding percentage (%) of students (provided for categorical measures) or means (provided for continuous measures). FAFSA filing status indicates whether students have a financial aid file in the ERC data, which means whether students filed for federal or state financial aid.

### Description of Students who Experience Course Repetition

I categorized horizontal and vertical repetition samples into two categories: ever-repeaters and never-repeaters. Table 3 shows student background characteristics and college experiences by the four distinct types (ever-horizontal repeater, never-horizontal repeater, ever-vertical repeater, and never-vertical repeaters). Considering ever- and never-repeaters, I will discuss horizontal and vertical repeaters by student background characteristics (race, gender, international status, and age) in the next paragraph.

Asian students (53%) have the highest rate of horizontal repetition among racial/ethnic groups, and international students (35.8%) have the lowest rate of horizontal repetition. Female students (42.1%) have a slightly higher rate than male students (38.6%). Ever-horizontal and never-horizontal repeaters are around the same age (19.1 and 19.7 years-old respectively). Black students (18.3%) and Hispanic students (18.5%) vertically repeated a course with the highest rate among all the other races. Male students (20.2%) have a dramatically higher vertical repeat rate than female students (15.7%). Never-vertical repeaters (19.5 years-old) are older than ever-vertical repeaters (18.7 years-old).

Table 3 shows college experiences of never- and ever- horizontal and vertical repeaters by FAFSA-filing status, Pell-grant recipient status, whether they switched their majors after transferring, enrollment status (part-time, full-time or mixed), cumulative developmental education credits, cumulative core credits, and cumulative field of study credits. Compared to non-FAFSA filers (38.7% in horizontal repetition and 15.6% in vertical repetition), FAFSA filers (41.4% in horizontal repetition and 18.5% in vertical repetition) have higher rates of both vertical and horizontal repetition in mathematics. While Pell recipients and Non-Pell recipients have similar horizontal repetition rates (respectively, 40.4% versus 40.9%), Pell recipients have higher rates of vertical repetition than non-Pell recipients (18.3% versus 17.1%).

Major switchers (44.1%) are 5 percentage points more likely to repeat horizontally than students who stay in the same major after transferring to a bachelor's degree granting institution (39.1%). Similarly, major switchers are higher vertical repeater compared to non-major switchers. Mixed-enrollment students were more likely than full-time and part-time students to experience both repetition types. While part-time students have a slightly higher rate of horizontal repetition compared to full-time students, the rate of vertical repetition is higher among full-time students than part-time students. Dual credit status is also associated with repetition. Students that had at least one dual credit course have lower rates of both vertical and horizontal repetition than students who did not have any dual credit courses (40.0% versus 40.9% in horizontal, and 16.5% versus 18.3% in vertical).

There were differences in numbers of cumulative developmental math, core, and field of study credits between ever- and never-repeaters in horizontal and vertical repetition. Ever-repeaters in vertical and horizontal categories accumulated more core and field of study credits before transfer than never-repeaters. Interestingly, on average, ever-horizontal repeaters (2.1 dev-ed math credits), who took more than one introductory college-level math course, accumulated fewer developmental math courses than never-horizontal repeaters (2.7 dev-ed math credits). Similarly, ever-vertical repeaters (2.1 dev-ed math credits), who repeated at least one same or lower-level math course in a specific sequence, on average, accumulated less developmental math courses than never-vertical repeaters (2.3 dev-ed math credits). This difference is contrary to my assumption that never-repeaters might have higher initial math ability. This result suggests that ever-repeaters in horizontal and vertical categories took less dev-ed mathematics credits before taking college-level courses. One possible explanation of this finding is that students who never repeated a math course developed necessary backgrounds by taking more developmental courses before taking a college-level math course. When never-repeaters start to take college level math courses, they do not repeat college-level math courses as much as ever-repeater students.

**Course Repetition and College Outcomes**

Table 4 shows the college outcomes of transfer students by their vertical and horizontal repetition status based on four indicators: earning a bachelor's degree within six years, the average time to bachelor's degree (by years), average excess credits, and cumulative GPA. Overall, on average, ever-horizontal repeaters have slightly higher desirable college outcomes than never-horizontal repeaters with regard to cumulative GPA and bachelor's degree attainment. Ever-horizontal repeaters had marginally higher GPAs than never-horizontal repeaters (3.32 versus 3.31). Furthermore, a slightly higher percentage of ever-horizontal repeaters (39%) finished a bachelor's degree within six years compared to never-horizontal repeaters (37%). On the other hand, among students who earned a bachelor's degree, ever-horizontal repeaters too them a little bit longer to finish a bachelor's degree (14.9 semesters versus 14.8 semesters). Also, they accumulated more credits than their never-horizontal repeater peers (about four credits).

***Table 4. Community College Transfer Students' College Outcomes by Their Course Repetition Categories***

| | Horizontal Repetition | | | | | Vertical Repetition | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Whole Sample | Ever-vertical repeaters | | Never-vertical repeaters | | Whole Sample | Ever-vertical repeaters | | Never-vertical repeaters | |
| | N | N | Mean | N | Mean | N | N | Mean | N | Mean |
| GPA | 33,205 | 13,489 | 3.32 | 19,716 | 3.31 | 36,079 | 6,394 | 3.18 | 29,685 | 3.36 |
| BA Attain-ment | 33,205 | 13,489 | 0.39 | 19,716 | 0.37 | 36,079 | 6,394 | 0.30 | 29,685 | 0.40 |
| Time to Degree | 12,32 | 5,191 | 4.966 | 7,138 | 4.940 | 13,799 | 1,945 | 5.001 | 11,854 | 4.926 |
| Excess Credits | 12,329 | 5,191 | 16.46 | 7,138 | 12.86 | 13,799 | 1,945 | 19.76 | 11,854 | 13.35 |

Notes: Bachelor's degree attainment refers to the transfer students who earn a bachelor's degree within six years. Among students who earn a bachelor's degree, time to degree was measured by the number of semesters that students attend at both a community college and a four year-institution. Total credits and GPA are measured as cumulative from community college and four-year institutions. Excess credits are the credits attempted by a community college transfer student that exceeded more than the bachelor's degree requirement (120).

### Regression Results

Table 5 shows the relationship between horizontal math course repetition and student outcomes. After controlling all the background characteristics and college experience indicators, the ever-horizontal repeater status does not predict cumulative GPA and bachelor's degree attainment in model 1 and model 2. In other words, ever- and never- horizontal repeaters have similar average cumulative GPA and bachelor's degree completion rate. However, model 3 and model 4 results revealed a positive relationship between horizontal repetition status and time to degree and excess credits. Specifically, after controlling all the other covariates, the model 3 results indicate that ever-horizontal repeaters took a little longer to finish a bachelor's degree (about 0.1 semesters). Model 4 results suggest that ever-horizontal repeaters accumulated more excess credits than their never-horizontal peers.

***Table 5.***

***OLS Regression Results Examining Relationship Between Horizontal Math Course Repetition and Various Student Outcomes (Cumulative GPA, Bachelor's Degree Attainment within Six-years, Time to Bachelor's Degree (Semesters) and Excess Credits)***

| | (Model 1) | (Model 2)[+] | (Model 3) | (Model 4) |
|---|---|---|---|---|
| Variables | Cumulative GPA | BA Attainment within 6-years | Time to Degree (Semesters) | Excess Credits |
| **Ever-Horizontal Repeater** | -0.001 | 0.005 | 0.101** | 3.593*** |
| | (0.006) | (0.005) | (0.035) | (0.290) |
| Student Backgrounds | X | X | X | X |
| College Experiences | X | X | X | X |
| Cohort Fixed-Effects | X | X | X | X |
| Observations | 29,675 | 29,675 | 11,942 | 11,942 |
| R-squared | 0.099 | 0.150 | 0.287 | 0.203 |

*Notes.* The table presents coefficients with standard errors in parentheses from ordinary least squares regression models performed on a pooled sample of community college students who entered college in 2011–2012 or 2012–2013. Model 1 and Model 2 include students who transferred to a four-year institution. Model 3 and Model 4 include those students who transferred to a four-year institution and earned a bachelor's degree within six years. All models include cohort fixed effects.

*** p<0.001, ** p<0.01, * p<0.05

[+]Logistic regression was also performed. The results of the logistic regression were similar to OLS regression. As the interpretation of the OLS regression model is easier, I performed to use the OLS model.

Table 6 shows the relationship between vertical math course repetition, and student outcomes (cumulative GPA, bachelor's degree attainment within six-years, time to degree, and excess credits). After controlling all the other variables, the model 1 outcomes indicate that ever-vertical repeaters had a lower cumulative GPA than their never-vertical peers. The model 2 results demonstrate that ever-vertical repeaters are 6.5 percentage points less likely to graduate with a bachelor's degree within six years of enrollment at a community college. Furthermore, ever-vertical repeaters took longer to finish a bachelor's degree than their never-vertical repeaters (0.16 semesters). Finally, ever-vertical repeaters accumulated more excess credits than never-vertical repeaters (5.3 credits).

***Table 6.***

***OLS Regression Results Examining Relationship Between Vertical Math Course Repetition and Various Student Outcomes (Cumulative GPA, Bachelor's Degree Attainment within Six-years, Time to Bachelor's Degree (Semesters) and Excess Credits)***

| | **(Model 1)** | **(Model 2)**[+] | **(Model 3)** | **(Model 4)** |
|---|---|---|---|---|
| Variables | Cumulative GPA | BA Attainment within 6-years | Time to Degree (Semesters) | Excess Credits |
| **Ever-vertical Repeaters** | -0.161*** | -0.065*** | 0.164*** | 5.290*** |
| | (0.007) | (0.007) | (0.047) | (0.390) |
| Student Backgrounds | X | X | X | X |
| College Experiences | X | X | X | X |
| Cohort Fixed-Effects | X | X | X | X |
| Observations | 32,334 | 32,334 | 13,346 | 13,346 |
| R-squared | 0.111 | 0.154 | 0.288 | 0.215 |

*Notes.* The table presents coefficients with standard errors in parentheses from ordinary least squares regression models performed on a pooled sample of community college students who entered college in 2011–2012 or 2012–2013. Model 1 and Model 2 include students who transferred to a four-year institution. Model 3 and Model 4 include those students who transferred to a four-year institution and earned a bachelor's degree within six years. All models include cohort fixed effects.

*** p<0.001, ** p<0.01, * p<0.05

[+]Logistic regression was also performed. The results of the logistic regression were similar to OLS regression. As the interpretation of the OLS regression model is easier, I performed to use the OLS model.

While ever-horizontal does not relate to higher or lower GPA and bachelor’s degree attainment rate, ever-vertical repeaters have lower GPA and lower rate of bachelor’s degree completion. Among transfer students who earned a baccalaureate within six years, it took both ever- vertical and horizontal repeaters longer to finish the bachelor’s degree and accumulate more excess credits. This study’s findings revealed that taking additional mathematics courses horizontally or vertically does not lead to lower GPA or the decrease in probability of earning a bachelor’s degree. However, students who repeat a college-level course had to spend more time in college and eventually take more credits than their degree requirements.

## Discussion and Implications

In this study, I describe the prevalence of math course repetition among community college transfer students in Texas. Descriptive findings illuminate that 40% of students take more than one introductory college-level math course (*horizontal repeaters*), and 17% of students repeat the same or lower math courses in the prescribed sequence (*vertical repeaters*). While it may be the case that some programs require more than one introductory college-level math course, the high rate of horizontal repetition highlights the need for colleges to examine program requirements, advising practices, and transfer processes to reduce unnecessary horizontal duplication. Additionally, the vertical repetition rate suggests that colleges may need to create processes to identify critical courses to provide in-semester supports when they are required. Overall, the findings indicate that colleges must examine student course-taking patterns to avoid the accrual of additional credits.

Implementing guided pathways at the state-level could improve students' math course-taking patterns. As community colleges continue to implement guided pathways, they should explicitly develop strategies to avoid course repetition, first focusing on preventing repetition within their institution and then working to prevent it from partner institutions. As recommended in the Texas Pathways strategy, institutions should create clear and coherent program maps that align community college and transfer university programs of study (Flores & Fabianke, 2019; Texas Success Center, 2020). Additionally, colleges can develop meta-majors, which are clusters of programs that lead to similar career goals. By choosing the same appropriate introductory math course for all programs of study in a meta-major, colleges can decrease horizontal repetition for students who enter with at least a broad idea of their area of interest (Texas Success Center, 2019). In line with the implementation of math pathways programs, such as the Dana Center Mathematics Pathways (DCMP), colleges should provide advising in K-12 partner institutions and during college onboarding to give students information about the specific introductory-level mathematics course aligned with their meta-major and career goals. Such planning and advising efforts stand to decrease horizontal course repetition.

One of the challenges that transfer students face is credit loss at a four-year institution (Monaghan & Attewell, 2015). Not all courses are transferable from community colleges or applicable to degree requirements at four-year institutions. As repeating a course is a form of credit loss (those credits now likely count as electives), I initially assumed that math course repetition mostly occurred at the university level (post-transfer). However, findings suggest that the majority of both vertical and horizontal repeats occur at the community college level, contradicting my assumption. Thus, unlike results in the credit loss literature, during the years under study in Texas, the majority of excess credits came from repeated courses within a single community college, suggesting that reforms at the community college level could have the most substantial impact of reducing excess credits due to math repetition in Texas.

To decrease course repetition among students, institutions could develop a couple of different strategies through the implementations of guided pathways. Community colleges could develop data analytics to reduce course repetitions and excess credits. Institutional research (IR) offices at community colleges could use this study's repetition identification strategy and apply it to examine patterns at their institutions. A similar process was outlined in Jenkins and Pellegrino's (2019) case study of San Jacinto College in Texas (presented at the guided pathways kickoff meeting) which highlighted the importance of using data to understand excess credits and demonstrated how the IR office at the college uses students' transcript to identify challenging courses. Similar to the San Jacinto College approach, I recommend that IR offices use data to identify critical courses that their students usually repeat, which will help them target pathways and sequences that could be improved.

Second, as the course repetitions vary by the students' first college-level mathematics course, departments, and advisors can use information gleaned from IR results to enhance their advising practices. For example, half of the calculus for business starters vertically repeated at least one time (either retook calculus for business or math for the business course again). It may be the case that students seeking admission to competitive business programs at a university retake the course to earn a better grade since grade replacement policies at some community colleges allow students to improve their GPAs before transfer. It could also be the case that the material in business calculus was challenging, and students required more support to pass the course. Advisors and business/math department faculty could work together to examine the reasons for this repetition pattern, ensure placement policies correctly identify readiness for calculus, and provide any necessary in-semester support to help students meet their transfer goals during the first attempt at business calculus.

Additionally, IR offices and math departments at community colleges can work together and create an early warning system/flag before students register for a course that appears to be a vertical or horizontal course repetition. Before registration, receiving a warning message about repeating a course paired with information about their program requirements might help students choose more appropriate coursework. Moreover, advisors can also make use of this information and discuss with students the consequences of repeating a course.

When refining programs and policies based on data, institutions should disaggregate by race, gender, and academic preparedness to examine student progress and pinpoint subgroups of students experiencing high rates of course repetition, similar to suggestions in the Texas Success Center's (2019) strategic plan. In the current study, findings from the disaggregated data revealed different results than aggregated data. For example, Asian students (53.0%) have the highest rate of horizontal repetition (53.0%), and vertical repetition (20.2%) among racial/ethnic groups (average horizontal repetition in the sample is 40.6%, see Table 2). On the other hand, while Hispanic students (38.1%) have a lower rate of horizontal repetition than average horizontal rate, the vertical repetition rate for Hispanic students (18.5%) is higher than the average rate. These results suggest that necessary changes to college practices may vary when taking into account the racial/ethnic makeup of repeaters.

The course repetition framework can be used to analyze course repetition patterns in community colleges and future research studies. Although the study used data before the implementation of guided pathways in Texas community colleges, the framework's current usefulness is two-fold: it can guide institutional teams implementing reforms improve efficiency in the transfer process to "optimize the applicability of community college credits" (Texas Success Center, 2019, p. 4) and provide a measure of institutional improvement during guided pathways reform efforts. Moreover, researchers can use the framework to apply the types of course repetitions to other contexts and student populations, as well as to analyze how the course repetition patterns changed over time (from one cohort to another cohort).

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***Table 5.***

***OLS Regression Results Examining Relationship Between Horizontal Math Course Repetition and Various Student Outcomes (Cumulative GPA, Bachelor's Degree Attainment within Six-years, Time to Bachelor's Degree (Semesters) and Excess Credits)***

| Variables | (Model 1)<br>Cumulative GPA | (Model 2)[+]<br>BA Attainment within 6-years | (Model 3)<br>Time to Degree (Semesters) | (Model 4)<br>Excess Credits |
|---|---|---|---|---|
| Ever-Horizontal Repeater | -0.001 | 0.005 | 0.101** | 3.593*** |
| | (0.006) | (0.005) | (0.035) | (0.290) |
| Race (Reference = White) | | | | |
| Asian | 0.051*** | -0.060*** | 0.025 | 3.407*** |
| | (0.013) | (0.012) | (0.078) | (0.640) |
| Black | -0.197*** | -0.033** | -0.254*** | 4.520*** |
| | (0.011) | (0.010) | (0.071) | (0.575) |
| Hispanic | -0.106*** | -0.048*** | 0.063 | 0.645* |
| | (0.007) | (0.006) | (0.040) | (0.323) |
| Two or More Race | -0.041** | -0.064*** | -0.281** | 0.607 |
| | (0.014) | (0.013) | (0.086) | (0.705) |
| Other | -0.045 | 0.041 | -0.202 | 0.690 |
| | (0.052) | (0.048) | (0.290) | (2.367) |
| Female (Reference = Male) | 0.117*** | 0.056*** | -0.215*** | -1.815*** |
| | (0.006) | (0.006) | (0.036) | (0.297) |
| International Student | 0.079* | -0.027 | -0.509* | -2.011 |
| | (0.032) | (0.030) | (0.199) | (1.623) |
| Age | 0.021*** | -0.001 | -0.035*** | -0.422*** |
| | (0.001) | (0.001) | (0.004) | (0.031) |
| Pell-grant Recipients | -0.015* | -0.074*** | 0.249*** | 1.908*** |
| | (0.008) | (0.007) | (0.046) | (0.375) |
| FADS status | 0.028*** | -0.041*** | 2.091*** | 6.707*** |
| | (0.008) | (0.008) | (0.048) | (0.392) |
| Enrollment Pattern (Reference = Part-time) | | | | |
| Full-time | 0.047* | 0.273*** | -0.443*** | 5.310*** |
| | (0.019) | (0.018) | (0.123) | (1.008) |
| Part-time | -0.018 | 0.146*** | -0.354** | 6.544*** |
| | (0.015) | (0.014) | (0.111) | (0.905) |
| The number of Stop-out | -0.108*** | -0.161*** | 0.116* | -5.425*** |
| | (0.005) | (0.005) | (0.046) | (0.377) |
| Earn Associate Degree | 0.094*** | -0.050*** | 0.180*** | 3.033*** |
| | (0.006) | (0.006) | (0.036) | (0.290) |
| Major Switchers | -0.032*** | -0.002 | -0.236*** | 3.851*** |
| | (0.006) | (0.006) | (0.038) | (0.308) |

| | | | | |
|---|---|---|---|---|
| Broad Major Category at community college | | | | |
| Broad Major #2 | 0.115*** | -0.127*** | 0.353* | 5.085*** |
| | (0.027) | (0.025) | (0.145) | (1.184) |
| Broad Major #3 | 0.068** | -0.015 | 0.294* | -1.995 |
| | (0.025) | (0.023) | (0.127) | (1.041) |
| Broad Major #4 | 0.047 | -0.000 | 0.087 | -4.138*** |
| | (0.027) | (0.025) | (0.140) | (1.141) |
| Broad Major #5 | 0.078* | -0.031 | 0.337 | -3.387* |
| | (0.033) | (0.031) | (0.179) | (1.460) |
| Broad Major #6 | 0.095*** | -0.147*** | 0.693*** | 2.129 |
| | (0.029) | (0.027) | (0.158) | (1.287) |
| Broad Major #7 | 0.134*** | -0.160*** | 0.876*** | 4.138** |
| | (0.029) | (0.027) | (0.167) | (1.366) |
| Broad Major #8 | 0.019 | -0.058* | 0.271* | -2.855** |
| | (0.025) | (0.023) | (0.132) | (1.077) |
| Broad Major #9 | 0.134*** | -0.198*** | 1.041*** | 10.572*** |
| | (0.028) | (0.026) | (0.164) | (1.342) |
| Broad Major #10 | 0.065** | -0.105*** | 0.450*** | -1.686 |
| | (0.024) | (0.022) | (0.123) | (1.008) |
| Broad Major #11 | 0.063* | -0.036 | 0.200 | 2.210 |
| | (0.030) | (0.028) | (0.159) | (1.300) |
| Broad Major #12 | 0.110*** | -0.150*** | 0.503*** | 0.473 |
| | (0.026) | (0.024) | (0.141) | (1.148) |
| Cum. Dev-ed Math Credits | -0.014*** | 0.197*** | -0.747*** | 1.324*** |
| | (0.001) | (0.005) | (0.041) | (0.053) |
| Cumulative GPA | | -0.017*** | 0.082*** | |
| | | (0.001) | (0.006) | |
| Cohort-2013 | 0.001 | 0.008 | -0.926*** | -4.470*** |
| (Reference = 2012) | (0.006) | (0.005) | (0.037) | (0.300) |
| Constant | 2.867*** | -0.122*** | 17.028*** | 129.223*** |
| | (0.031) | (0.033) | (0.220) | (1.482) |
| Observations | 29,675 | 29,675 | 11,942 | 11,942 |
| R-squared | 0.099 | 0.150 | 0.287 | 0.203 |

*Notes*. The table presents coefficients with standard errors in parentheses from ordinary least squares regression models performed on a pooled sample of community college students who entered college in 2011–2012 or 2012–2013. Model 1 and Model 2 include students who transferred to a four-year institution. Model 3 and Model 4 include those students who transferred to a four-year institution and earned a bachelor's degree within six years. All models include cohort fixed effects.

*** p<0.001, ** p<0.01, * p<0.05

[+]Logistic regression was also performed. The results of the logistic regression were similar to OLS regression. As the interpretation of the OLS regression model is easier, I performed to use the OLS model.

***Table 6.***
***OLS Regression Results Examining Relationship Between Vertical Math Course Repetition and Various Student Outcomes (Cumulative GPA, Bachelor's Degree Attainment within Six-years, Time to Bachelor's Degree (Semesters) and Excess Credits)***

| | (Model 1) | (Model 2)[+] | (Model 3) | (Model 4) |
|---|---|---|---|---|
| Variables | Cumulative GPA | Bachelor's Degree Attainment | Time to Degree by Semesters | Excess Credits |
| Ever-vertical Repeaters | -0.161*** | -0.065*** | 0.164*** | 5.290*** |
| | (0.007) | (0.007) | (0.047) | (0.390) |
| Race (Reference = White) | | | | |
| Asian | 0.070*** | -0.046*** | -0.045 | 3.678*** |
| | (0.012) | (0.011) | (0.069) | (0.563) |
| Black | -0.190*** | -0.038*** | -0.242*** | 3.801*** |
| | (0.010) | (0.010) | (0.068) | (0.559) |
| Hispanic | -0.105*** | -0.053*** | 0.071 | 0.322 |
| | (0.006) | (0.006) | (0.038) | (0.310) |
| Two or More Race | -0.035** | -0.059*** | -0.238** | 1.195 |
| | (0.013) | (0.012) | (0.081) | (0.662) |
| Other | -0.013 | 0.025 | -0.091 | 1.565 |
| | (0.049) | (0.046) | (0.277) | (2.278) |
| Female (Reference = Male) | 0.108*** | 0.057*** | -0.236*** | -1.635*** |
| | (0.006) | (0.005) | (0.034) | (0.283) |
| International Student | 0.098*** | -0.018 | -0.511** | -2.445 |
| | (0.029) | (0.027) | (0.176) | (1.442) |
| Age | 0.020*** | -0.001* | -0.035*** | -0.318*** |
| | (0.001) | (0.001) | (0.004) | (0.030) |
| Pell-grant Recipients | -0.016* | -0.073*** | 0.271*** | 2.050*** |
| | (0.007) | (0.007) | (0.043) | (0.356) |
| FADS status | 0.035*** | -0.038*** | 2.091*** | 6.839*** |
| | (0.008) | (0.007) | (0.045) | (0.370) |
| Enrollment Pattern (Reference = Part-time) | | | | |
| Full-time | 0.055** | 0.263*** | -0.363** | 5.765*** |
| | (0.018) | (0.017) | (0.114) | (0.939) |
| Mixed enrollment | -0.008 | 0.142*** | -0.267** | 6.920*** |
| | (0.015) | (0.014) | (0.102) | (0.840) |
| The number of Stop-out | -0.107*** | -0.166*** | 0.095* | -5.561*** |
| | (0.005) | (0.005) | (0.044) | (0.362) |
| Earn Associate Degree | 0.085*** | -0.055*** | 0.217*** | 3.356*** |
| | (0.006) | (0.005) | (0.034) | (0.279) |
| Major Switchers | -0.027*** | -0.002 | -0.211*** | 3.851*** |
| | (0.006) | (0.005) | (0.036) | (0.293) |

| | | | | |
|---|---|---|---|---|
| Broad Major Category at community college | | | | |
| Broad Major #2 | 0.138*** | -0.099*** | 0.290* | 4.571*** |
| | (0.026) | (0.024) | (0.138) | (1.133) |
| Broad Major #3 | 0.069** | -0.010 | 0.263* | -1.765 |
| | (0.024) | (0.023) | (0.125) | (1.028) |
| Broad Major #4 | 0.042 | -0.002 | 0.052 | -3.879*** |
| | (0.026) | (0.025) | (0.137) | (1.127) |
| Broad Major #5 | 0.068* | -0.028 | 0.287 | -2.972* |
| | (0.033) | (0.031) | (0.175) | (1.435) |
| Broad Major #6 | 0.084** | -0.145*** | 0.648*** | 2.647* |
| | (0.028) | (0.026) | (0.154) | (1.266) |
| Broad Major #7 | 0.162*** | -0.101*** | 0.604*** | 3.555** |
| | (0.027) | (0.026) | (0.147) | (1.210) |
| Broad Major #8 | 0.014 | -0.058* | 0.225 | -3.168** |
| | (0.025) | (0.023) | (0.129) | (1.062) |
| Broad Major #9 | 0.173*** | -0.169*** | 0.746*** | 8.478*** |
| | (0.026) | (0.025) | (0.147) | (1.207) |
| Broad Major #10 | 0.071** | -0.103*** | 0.440*** | -0.694 |
| | (0.023) | (0.022) | (0.121) | (0.995) |
| Broad Major #11 | 0.052 | -0.030 | 0.191 | 2.331 |
| | (0.029) | (0.028) | (0.156) | (1.283) |
| Broad Major #12 | 0.105*** | -0.152*** | 0.525*** | 1.991 |
| | (0.025) | (0.024) | (0.138) | (1.136) |
| Cum. Dev-ed Math Credits | -0.015*** | -0.018*** | -0.747*** | 1.234*** |
| | (0.001) | (0.001) | (0.039) | (0.052) |
| Cumulative GPA | | 0.193*** | -0.954*** | -5.233*** |
| | | (0.005) | (0.035) | (0.319) |
| Cohort-2013 | -0.001 | 0.007 | 0.084*** | -4.802*** |
| (Reference = 2012) | (0.005) | (0.005) | (0.006) | (0.285) |
| Constant | 2.917*** | -0.081* | 16.971*** | 145.308*** |
| | (0.030) | (0.032) | (0.211) | (1.732) |
| Observations | 32,334 | 32,334 | 13,346 | 13,346 |
| R-squared | 0.111 | 0.154 | 0.288 | 0.215 |

*Notes.* The table presents coefficients with standard errors in parentheses from ordinary least squares regression models performed on a pooled sample of community college students who entered college in 2011–2012 or 2012–2013. Model 1 and Model 2 include then students who transferred to a four-year institution. Model 3 and Model 4 include those students who transferred to a four-year institution and earned a bachelor's degree within six years of enrollment. All models include cohort fixed effects.

*** p<0.001, ** p<0.01, * p<0.05

+Logistic regression was also performed. The results of the logistic regression were similar to OLS regression. As the interpretation of OLS regression.