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Abstract

Over the past 12 years, a large public research University in the southern part of the United States implemented three math developmental models consecutively. These developmental models all strive to equip developmental students with better math skills before they embark on college level credit bearing courses. With pre-requisite developmental models called into question by educators, the co-requisite developmental model has gained prominent support in recent years. This paper examined closely the effectiveness of these various models based on three quantifiable matrices: pass rate, duration for completion and enrollment consistency. Most importantly, the long existing racial disparities in developmental outcomes have also been thoroughly investigated and compared between developmental models based on data-driven analysis.

Introduction

A college education has become increasingly necessary to secure reliable middle-class employment(Stetser et al., 2014). For several historically disadvantaged racial groups, particularly African American and Hispanics, education is the primary means of status advancement (Bailey & Morest, 2006; Kerckhoff, 2001). However, the disparities in school readiness among America's children begin as early as kindergarten. Early learning disadvantages are likely to persist through their school years and into adulthood (García et al., 2015). With recent high school graduation rates at an all-time high of 80% (Stetser et al., 2014), a staggering 43% of those students who begin college do not earn a degree after six years (U.S. Department of Education, National Center for Education Statistics, 2010). Many of these students come to college underprepared, however it would be impractical to send an academically disadvantaged adult back to high school to acquire prerequisite skills. Alternatively, postsecondary remediation, commonly referred to as developmental education, serves the purpose of resolving deficiencies that obstruct access to postsecondary credentials (Peter Riley, 2010).

According to a comprehensive study by the Department of Education in 2006, 83% of 12th graders who took calculus in high school graduated college within 8 years, compared with only 40% of those who stopped at algebra 2 (Adelman et al., 2006). A previous study found that 27% of new entrants to college require at least one math developmental course to earn a Bachelor's of Arts degree (Livingston et al., 2003), however only less than 31% of students enrolled in math developmental course complete all of the recommended developmental sequence (Bailey, 2009).

In this study, three different developmental models (Model 1, Model 2, and Model 3) were studied closely to examine their effectiveness based on data gathered at a public research university in the South. At this university, students are placed into different levels of mathematics courses according to their college entrance and placement test scores, such as SAT or ACT. If meeting or

exceeding certain score cut offs, students are placed directly into gateway course such as college algebra (CA) or quantitative method reasoning (QMR), both of which are credit bearing college-level courses. If falling short of the cut offs, students are placed in developmental courses, either before they can start gateway courses or concurrently, depending on the developmental model.

Previous models, Model 1 and Model 2, placed students based on a prerequisite model. Model 1 required all developmental students to complete one or two prerequisite courses before they could enroll in a gateway course. Model 2 adopted an emporium style computer based modularized approach, first emerged and adopted at Virginia Tech (Twigg, 2011), where developmental students could work through pre-requisite course material at their own pace before starting a gateway course.

The current model, Model 3, allows developmental students whose test scores are close to the gateway math cut off to be placed into co-requisite courses. This allows these students to not only enroll in the gateway course with gateway students but also simultaneously enroll in a one-hour developmental course that's supplemental to the gateway course material. Under Model 3, developmental students whose test scores are lower are placed in a foundations course as a prerequisite to the gateway course.

To measure success through multiple matrices, developmental students' pass rates in gateway courses, total duration for completion, and enrollment consistency were investigated for each model. Further comparisons based on these three matrices were drawn between minority students and Caucasian students to further assess the effectiveness of developmental course on historically disadvantaged minority students. Based on rigorous quantitative analysis, this study uncovers the impact that this new developmental model has on fostering success among academically unprepared students at the college level and promoting racial equalities in an education setting.

Literature Review

Multiple studies echoed with the research findings by Complete College America that long developmental education course sequences are a barrier, not a bridge to college (Vandal & Complete College, 2014). The reasons are varied. Some believe that being placed in a developmental class, a type of prerequisite noncredit bearing course and being separated from their 'more advanced' peers induces a mindset of self-deficiency. This could convey stigma or negative expectations about a students' capacity to learn math. If they internalize these expectations, it may tend to undermine their motivation to learn and hence their outcomes (Dweck, 2006; Oakes, 2005). Others believe this negative impact comes from low classroom peer skills, as teachers have been found to pitch the level, expectation, and pace of instruction to the median level of prior skills of the students in the classroom (Hallinan, 2000; Pallas et al., 1994). Therefore, being grouped with students who are less skilled reduces one's exposure to more rigorous course content than being grouped with more skilled students. Some studies have also pointed out the between-term gap that, for some students, has served as an off-ramp from the math track by allowing them to simply not enroll in subsequent courses (Strother et al., 2019).

To prevent the loss of students during the sometimes long and stigmatizing prerequisite developmental classes, many institutions have moved to a co-requisite model (Rutschow et al., 2018). Unlike the pre-requisite model, the new corequisite courses are designed as a one-term offering. Students who would otherwise be placed in pre-requisite developmental classes can now take a credit bearing college level gateway course right from the start. Co-requisite models can be set up in different ways, but oftentimes students enroll in a developmental course the same semester as the college-level course. By enrolling in the developmental course during the same semester, this helps students grasp concepts that are necessary in understanding the material taught in the gateway course. Arguably, the co-requisite model could shorten the time it takes students to earn college-level math or statistics credit. As indicated in one study by Carnegie Math Pathways, 65.1% of 410 students from six colleges

who participated in new co-requisite offerings were successful in completing the courses in a single term (Stephens et al., 2019). By contrast, research has shown that only 6% of students who were placed in a traditional developmental math sequence achieve college-level math credit within a single year (Rutschow et al., 2018).

There has been overwhelming evidence to suggest that the corequisite model is more effective than the traditional developmental model in moving students through gateway courses (Rutschow et al., 2018; Texas Higher Education Coordinating, 2014; Vandal & Complete College, 2014) However, because past studies were carried out among various student cohorts and across a wide range of locations, it's difficult to control other possible contributing factors when studying the discrepancy of success among different developmental models. Most recently, The Carnegie Math Pathways study shows developmental success rates vary by institution and (within institutions that offered multiple sections) by section (Strother et al., 2019). Therefore, in order to validate prior research findings, it is vital that comparison between developmental models be made in a consistent educational setting with knowledge of students' demographic mix.

Also, prior studies often used the pass rate of developmental courses within a certain period as a singular measure of success (Strother et al., 2019; Vandal & Complete College, 2014). While pass rate is concise and easy to understand, it does not give enough attention to how well students transition from developmental courses to gateway courses. The duration of completion and enrollment consistency has long been overlooked to fully comprehend the effectiveness of various developmental models (Parsad et al., 2003).

Prior studies have also found that social-class disparities could affect people's access to and performance in professional education (García et al., 2015; Stephens et al., 2019). More specifically, math developmental success rates - the subject in which the greatest number of students require assistance – differ substantially by race (García et al., 2015; Peter Riley, 2010; Stetser et al., 2014).

Generally, racial groups that tend to be disadvantaged in math achievement, namely African Americans and Hispanics, also experience low rates of successful developmental (Peter Riley, 2010). However, it is unclear if racially disadvantaged groups are still left behind as developmental models have been modified over the years. This study draws comparison between students who identify as Caucasian and their peers. Overall, based on previous and emerging research developments in the domain of mathematics developmental education, this paper answers the following research questions:

How do different mathematics developmental models compare with regards to pass rates, duration for completion, and enrollment consistency?

Does the co-requisite model have any impact on narrowing the racial disparities among academically vulnerable students upon college entry?

Data Collection and Analysis

This study looks at data from a public research university in the southern part of the United States. It is ranked No. 1 in its state by U.S. News and World Report for social mobility, which measures a university's success in graduating economically disadvantaged students who are less likely to finish college (https://www.usnews.com/best-colleges/rankings/national-universities/social-mobility). At this institution, 47% of undergraduate students from the fall 2020 semester received Federal Pell Grant, a federal aid awarded to undergraduate students with exceptional financial need, and 48% of undergraduates are first-generation students. The student body is one of the most diverse of surrounding colleges and institutions. More than half of the students are over the age of traditional college students of 25, with an overall average age of 27.

For this study, data spanned the period from fall 2009 to spring 2020 and contained information on student demographic characteristics and academic performances. From fall 2009 to spring 2020, a total of 16,254 students enrolled in at least one developmental or gateway math courses. Of all those students, 6,932 (42.65%) were identified as needing developmental course, whom we call developmental students. Of all the developmental students, there were more female (61.66%) than male (38.3%), more over the age of 25 (68.64%) than traditional age 25 or younger (31.36%), and more minority (58.04%) than Caucasian (41.96%). Of all the minority developmental students, 2,646 (65.77%) were African American, 674 (16.75%) two or more races, 306 (7.61%) non-resident aliens, 235 (5.84%) Hispanic, 69 (1.72%) Asian, 64 (1.59%) unknown or refused to report, and 29 (0.72%) American Indian. See Table 1.

Table 1

Sociodemographic Characteristics of Students Studied 2009-2020

Gender		**Frequency**	**Percent**
Female		4274	61.66%
Male		2655	38.30%
Unknown		3	0.04%
Age		**Frequency**	**Percent**
=<25		2174	31.36%
>25		4758	68.64%
Race or ethnicity		**Frequency**	**Percent**
Caucasian		2909	41.96%
Minority		4023	58.04%
	American Indian	29	0.72%
	Asian	69	1.72%
	African American	2646	65.77%
	Hispanic	235	5.84%
	Non-Resident Alien	306	7.61%

	Two or More Races	674	16.75%
	Unknown or Refused to Report	64	1.59%

At this institution, three developmental models were implemented consecutively during the studied period.

The first model, Model 1, was in place from fall 2009 to summer 2012, and consists of a traditional developmental mathematics course sequence: Elementary Algebra for lower performing students and Intermediate Algebra for middle performing students as pre-requisites to the college-level gateway course.

The second model, Model 2, replaced Model 1 in fall 2012. It was developed and based on a new design, the emporium model, originated at Virginia Tech (Twigg 2011). Called the Pre-Core program, all developmental mathematics students started in the course Pre-Core I. There were ten modules to complete to be eligible to enroll in College Algebra and eight modules to complete to be eligible to enroll in Quantitative and Mathematics Reasoning (QMR, a course designed for non-STEM majors). If students did not complete all required modules in Pre-Core I, they then enrolled in Pre-Core II, Pre-Core III, and Pre-Core IV sub sequentially until all modules were completed.

Lastly, the third model, Model 3, replaced Model 2 in summer 2016. It was designed based on the concept of co-requisite courses which have proven to be more effective in multiple studies (Strother et al., 2019; Texas Higher Education Coordinating, 2014; Vandal & Complete College, 2014). In this model, high needs students enroll in a Foundations course (either Foundations of College Algebra or Foundations of QMR, depending on the pathway - STEM or non-STEM), and middle needs students enroll in a pair of co-requisite courses (either co-requisite College Algebra and Lab or co-requisite QMR and Lab, again, depending on pathway). During the lab hour, students work in either small groups or one-on-one and spend more time on topics from the gateway course. The co-requisite courses allow developmental students to enroll directly in the college-level course during the same

semester as a one-hour developmental course, thus bypassing standalone developmental course. Students who first enroll in the Foundations course must pass with a C or higher before enrolling in the gateway course.

In summary, both Model 1 and Model 2 require developmental students to pass noncredit developmental courses before they are allowed to attempt credit-bearing college-level gateway courses. In Model 1 students must finish either one or two developmental courses, depending on their placement score, whereas in Model 2, there is more flexibility since it's module-based and in theory enables students to manage their own progress. Unlike the previous two models, Model 3 adopted a partially co-requisite model where developmental students who tested within a certain range are allowed to take college-level courses directly as long as they enroll in a one-hour developmental lab at the same time. Developmental students who test below this cutoff must finish a prerequisite foundations course before they can attempt the college-level course. It is important to note that even though different ways to subdivide developmental students were utilized under various models, the cut-off between gateway students and developmental students have been consistent throughout the years. See Table 2. This way, we ensured that prior skills and abilities of developmental students were not to influence the outcome of each model by design.

Table 2

Summaries of remediation models and gateway course

Model	Semesters Implemented	Placement score (ACT)	Course Type	Course Registration Number	Course Sequence	Model Structure	N
1	2009 Fall - 2012 Summer	ACT less than 19	Developmental	300	Elementary Algebra	Need to pass intermediate algebra before enrolling in gateway courses	2666
		ACT 19-20	Developmental	301	Intermediate Algebra		

2	2012 Fall - 2016 Spring	ACT less than 21	Developmental	0321, 0322, 0323, 0324	8 Pre-core modules for QMR or 10 pre-core modules for college algebra	Need to finish 8 or 10 pre-core modules before enrolling in gateway courses	2092
3	2016 Summer - 2020 Spring	0332 ACT less than 18	Developmental	0332 or 0330 dependent on pathway	Foundation	Need to pass foundations course before enrolling in gateway course	2174
		0330 ACT less than 16					
		1302/0102 ACT 18-20	Developmental & gateway	1302 & 0102 or 1321 & 0121 dependent on pathway	Co-requisite course	Need to take lab with co-requisite gateway courses	
		1321/0121 ACT 16-17					
Gateway	2009 Fall - 2020 Spring	1302 ACT 21+	Gateway	1302 or 1321	Gateway course	Direct enrollment in gateway courses	9322
		1321 ACT 18+					

Methodology

Given the end goal of math developmental course is to help students enroll in and complete gateway courses, we gathered data on gateway course pass rates of developmental students. We then compared the pass rate under three developmental models to identify any differences.

Second, this study calculated the total duration for a student to complete both his developmental and gateway courses. It was calculated as the number of semesters elapsed from start to finish. For example, if a student started taking their developmental course in spring 2018 and ended up completing their gateway course in fall 2019, the total duration would be 6 semesters, including summer.

Third, this study calculated enrollment consistency to reveal how consistently a student stayed enrolled before they passed a gateway course. It was calculated as the number of semesters during which a student stayed enrolled divided by the number of semesters elapsed from start to finish. Taking from the previous example where a student had a total duration of 4 semesters to complete, if they stayed enrolled for 3 out of the 4 semesters, the enrollment consistency would be ¾=0.75.

Descriptive statistics was utilized in this study. The mean and standard deviation of duration and enrollment consistency under each developmental model was calculated. Using duration as the response variable, developmental model as independent variable, and comparing Model 1 and Model 2 with Model 3, a generalized linear model was used to identify any significant differences in duration between different developmental models. The same method was applied for enrollment consistency. Model 1 and Model 2 were compared with Model 3. Model 3 incorporated co-requisition developmental course by dividing developmental students into two groups, foundation students and corequisite students. Corequisite students are allowed to take a gateway course with their more advanced peers, and we are interested in finding out whether this improves the success of developmental students in college credit math courses.

Lastly, we compared the performance of Caucasian students and their minority peers under different developmental models. Pass rates of these two groups of students were compared using Chi-Square tests for each of the developmental models. T-test was also performed to make comparison of duration and enrollment consistency between these two groups under various developmental models. Significance level is set at 0.01.

Results

Pass rate of Gateway Course

Under Model 1, the percentage of developmental students eventually passing a gateway course is 26.18% (N=698). It is 27.06% (N=703) under Model 2 and 55.06% (N=1197) under Model 3. Within Model 3, among all the foundation students, 28.26% (N=217) of them passed gateway course. By contrast, among all the co-requisite students under Model 3, 69.70% (N=980) passed gateway course. See Table 3. While there is little difference in pass rates between Model 1 and Model 2, Model 3 doubled the pass rate for developmental students compared with the former two models. See Table 3.

Table 3

Gateway Course Pass Rate Comparison: By Remediation Model Types

Model	**1**	**2**	**3**	
			Foundation	**Co-requisite**
Pass rate	26.18%	27.06%	28.26%	69.70%
			55.06%	

Total duration

Among developmental students who have passed gateway courses, there is little difference between the total duration of Model 1 (N=887, Mean=5.6009, STD= 5.5873) and that of Model 2 (N=888, Mean=5.6171, STD =5.1028). However, Model 3 greatly shortens the total duration (N=1696, Mean=3.1197, STD=2.3615) and is significantly different from Model 1 and Model 2 ($F=154.79$, $p<0.0001$). See Table 4.

Table 4

Total Duration of Completing Final Gateway Course Comparison: By Model Types

STARTMODEL	N	TDUR			
		Mean	Std Dev		
1	887	5.60090192	5.58726374		
2	888	5.61711712	5.10275693		
3	1696	3.1196934	2.3615282		
Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
compare control with 1,2	1	5374.395557	5374.395557	309.57	<.0001

Enrollment consistency

Enrollment consistency is similar between Model 1 (N=887, Mean=0.8305, STD=0.2522) and Model 2 (N=888, Mean=0.8233, STD=0.2390) for developmental students who have passed gateway courses. However, Model 3 greatly increases the enrollment consistency (N=1696, Mean=0.9409, STD=0.1651) and is significantly different from Model 1 and Model 2 ($F=254.83$, $p<0.0001$). See Table 5.

Table 5

Enrollment Consistency Comparison: By Model Types

STARTMODEL	N	EC			
		Mean	Std Dev		
1	887	0.83049761	0.25218285		
2	888	0.82333636	0.23904776		
3	1696	0.94085395	0.16508199		
Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
compare control with 1,2	1	11.25897452	11.25897452	254.83	<.0001

Comparison by race or ethnicity

Pass rate

The pass rates of Caucasian students are consistently higher than their minority peers throughout the three developmental models. The pass rate for Caucasian students is 30.75% compared with 22.37% for minority students (X^2 (1, N = 2666) = 24.0366, p <0.0001) under Model 1. It is 39.74% for Caucasian students compared with 29.34% for minority students (X^2 (1, N = 2092) = 24.5725, p <0.0001) under Model 2. Under Model 3, pass rate is 62.05% for Caucasian students and 50.67% for minority students (X^2 (1, N = 2174) = 26.9475, p <0.0001). See Table 6.

Table 6

Pass Rate Comparison: By Model Types and Between Races

Model	Pass Rate		Chi-Square p-value
1	Caucasian	Minority	<0.0001
	30.75	22.37	
2	Caucasian	Minority	<0.0001
	39.74	29.34	
3	Caucasian	Minority	<0.0001
	62.05	50.67	

Total duration

T-test reveals that differences in total duration between Caucasian students and minority students are not statistically significant under Model 1, 2 or 3. However, it is noticeable that on average Caucasian students experienced shorter duration (N=470, Mean=5.366, STD=5.1405) than their minority peers (N=417, Mean=5.8657, STD=6.0468) under Model 1 (p=0.1838). It is also the case

under Model 2 (p=0.1247) where Caucasian students (N=409, Mean=5.3325, STD=5.1069) complete their developmental and gateway course faster than their minority peers (N=479, Mean=5.8601, STD=5.092). Then, this trend reversed. Caucasian students' total duration (N=671, Mean=3.2042, STD=2.6517) exceeded their minority peers (N=1025, Mean=3.0644, STD=2.1501) under Model 3 (p=0.2334). See Table 7.

Table 7

Total Duration Comparison: By Models and Races

Model	Race or Ethnicity	N	Mean	Std Dev	Std Err	Minimum	Maximum	T-test p-value
1	MINORITY	417	5.8657	6.0468	0.2961	2	36	0.1838
	CAUCASIAN	470	5.366	5.1405	0.2371	2	35	
2	MINORITY	479	5.8601	5.092	0.2327	2	40	0.1247
	CAUCASIAN	409	5.3325	5.1069	0.2525	2	47	
3	MINORITY	1025	3.0644	2.1501	0.0672	2	26	0.2334
	CAUCASIAN	671	3.2042	2.6517	0.1024	2	25	

Enrollment consistency

No statistically significant difference in enrollment consistency has been found between Caucasian students and their minority peers using t-test under Model 1, 2 or 3. However, on average, Caucasian students are more consistently enrolled (N=470, Mean=0.8313, STD=0.2598) than their minority peers (N=417, Mean=0.8296, STD=0.2436) under Model 1 (p=0.9226). So is the case under Model 2 (p=0.1027) where Caucasian students have a higher enrollment consistency (N=409, Mean=0.8375, STD=0.2365) than their minority peers (N=479, Mean=0.8112, STD=0.2408). It is the opposite under Model 3 (p=0.2384) where Caucasian students experienced lower enrollment consistency (N=671, Mean=0.935, STD=0.1853) than their minority peers (N=1025, Mean=0.9447, STD=0.1503). See Table 8.

Table 8

Enrollment Consistency Comparison: By Models and Races

Model	Race or Ethnicity	N	Mean	Std Dev	Std Err	Minimum	Maximum	T-test p-value
1	MINORITY	417	0.8296	0.2436	0.0119	0.12	1.5	0.9226
	WHITE	470	0.8313	0.2598	0.012	0.1154	1.5	
2	MINORITY	479	0.8112	0.2408	0.011	0.1429	1	0.1027
	WHITE	409	0.8375	0.2365	0.0117	0.1277	1	
3	MINORITY	1025	0.9447	0.1503	0.0047	0.1154	1.5	0.2384
	WHITE	671	0.935	0.1853	0.00716	0.15	1.5	

Discussion

Our study examined differences in developmental outcomes under three distinct models. The overall outcome of developmental students from developmental Model 3 is better than those from Model 1 and 2. They are more likely to eventually pass a college-level gateway course while spending shorter time doing so. They also experience fewer enrollment gaps during the period of math developmental and gateway courses, as shown by their higher enrollment consistency.

There is reasonable basis to believe that students' superior growth stems from the effectiveness of the Model 3 itself, rather than their prior skills or abilities. Students with ACT score higher than 21 were consistently placed into gateway groups and were not included in any developmental classes. This has been the case throughout the study period from year 2009 to 2020, and thus it is consistent under Model 1, 2 and 3. There has been no report on major shift in the selection criteria during admission, so it is safe to assume that the overall student body had similar prior skills. Given that the placement process has been objective and consistent as mentioned before, developmental students under Model 3 have had the same starting point as those under Model 1 or 2, to the best our ability to measure prior skills.

Several factors might have played into Model 3's better outcome. One possible contributing factor to Model 3's success is that it eliminated the gap between enrolling in developmental courses and gateway courses by offering co-requisite courses. As one study has pointed out, many students may successfully complete their developmental education courses and never even enroll in the gateway courses (Vandal & Complete College, 2014). Closing this gap not only helped to improve success rates, but also shortened the time it takes to complete a credit-bearing college-level gateway course. As is shown in Table 3, total duration for completing a gateway course is 3.11 semesters for a developmental student under Model 3. It is a little more than a half of the average time it took Model 1 (5.60 semesters) or Model 2 (5.62 semesters) students. Similarly, enrollment consistency among developmental students improved substantially from 0.83 under Model 1 and 0.82 under Model 2 to 0.94 under Model 3. A shorter duration and more consistent enrollment in turn increase likelihood of successful completion (Vandal & Complete College, 2014) and hence creates a virtuous circle for the co-requisite model to produce welcoming results.

There's also been research showing that not only is there a disproportionately higher need for developmental course among African American and Hispanic students, but they do not benefit as much from developmental course as do Caucasian students (Peter Riley, 2010). As another study pointed out, race or ethnicity by itself does not induce disadvantages in education. Rather, social class is the single most influential factor on students' readiness to learn. Race and ethnicity are usually associated with students' social economic class and compound the disadvantages associated with low social class (García et al., 2015).

It is therefore crucial to break the vicious cycle for minority students so that they can truly reap the benefit of developmental course by completing their bachelor's degree and gaining access to middle class employment. The faster they can move through college, the less they must spend on college and the more money they can make through working. It is therefore promising to see that Model 3 reversed the trend in Model 1 and 2 where minority students had lower success rates, longer

duration for completion and lower enrollment consistency on average. This is particularly important because a door of opportunity to close the racial disparity in social economics status is thus created at the postsecondary education level, with its impact leveraging far into one's later life.

As noted by prior studies, differences in structural resources and cultural barriers experienced by minority students could contribute to social-class disparities in U.S. higher education institutions, undermining these students' opportunity to succeed (Stephens et al., 2019). Arguably, by situating math content in context that are relevant to students' lives, we can increase engagement for students from disadvantaged social backgrounds (Texas Higher Education Coordinating, 2014). For example, educators can contextualize math content in topics relating to personal finance, social justice, or immigration policy to further encourage participation from a diverse background of students.

Conclusion

Results have shown that compared with prior models, developmental Model 3 dramatically increased developmental students' pass rates in gateway math courses. It also shortened the duration for which developmental students complete their gateway math courses and allowed for more consistent enrollment. Furthermore, this study has shown that minority students reaped greater benefit from developmental Model 3, as their gateway course pass rate improved faster than their Caucasian counterparts.

Limitations

This study collected data from fall 2009 to spring 2020. These cut-off dates meant some earlier students might have taken longer to complete their developmental and gateway courses under Model 1 or Model 2. By contrast more recent students, mostly likely those enrolled under Model 3, would have been able to complete their courses if allowed more time in our study. The likely effect of this scenario is that the total duration of completion under Model 1 and Model 2 might be longer and pass

rate under Model 3 might be even higher if we were to extend our studied period. If this is the case, our results showing superior performance of Model 3 would be more amplified.

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