Math Preparation Workgroup – Report
February 13, 2025

1. Introduction

EVC Simmons charged the Senate-Administration Workgroup on Math Preparation in Winter 2024 to examine the fact that an increasing number of students are placing into classes that precede the calculus sequences (Math 2, 3C, and 4C); the focus of the charge was to evaluate equity gaps in initial Math coursework and downstream effects (see Workgroup Charge, Appendix). By 'equity gaps', we mean disparity in things such as course placements, course grades, and retention and graduation rates when the data are disaggregated by demographic factors such as race, ethnicity, income levels. These are downstream effects of inequitable primary and secondary education, which, in turn, is due to inequitable societal structures. It is important to emphasize that this report does not place the blame for these gaps on our students, faculty, or staff. Rather, the report asks how our university can work to disrupt these inequities.

The group met thirteen times between Winter 2024 and Winter 2025. The discussions were far-ranging and touched on various aspects of math preparation. Given the complexities of this area, it became clear that there are no easy solutions. Nonetheless, the following report discusses current initiatives, recommends possible new directions, and identifies areas for further investigation.

A large percentage of UC San Diego students need to complete some calculus for their major or general education (ranging from about 74% to 80% over the past five years). The Department of Mathematics offers two series – Math 10 and Math 20; the former is mainly for Biology and Social Science students; the latter for Engineering, Mathematics, and Physical Sciences. The 20 series is considerably more rigorous than the 10 series. Through the Math Placement Exam and other measures, students are placed into the relevant courses; students who do not place directly into calculus may take Math 3B and/or 3C (pre-calculus for the 10 series), 4C (pre-calculus for the 20 series), or Math 2 – a preparatory course for students who do not place into 3B, 3C or 4C.

The 2022-23 academic year saw a sharp increase in the number of first-year students placing into Math 2 or 3C; Math 2 placement further increased in 2023-24.[1]

[1] This report will focus exclusively on first-time, first-year students (i.e., those who enter from high school). Essentially all majors that require calculus have transfer major preparation requirements that ensure that transfer students in those fields will have completed calculus before matriculating at UC San Diego.

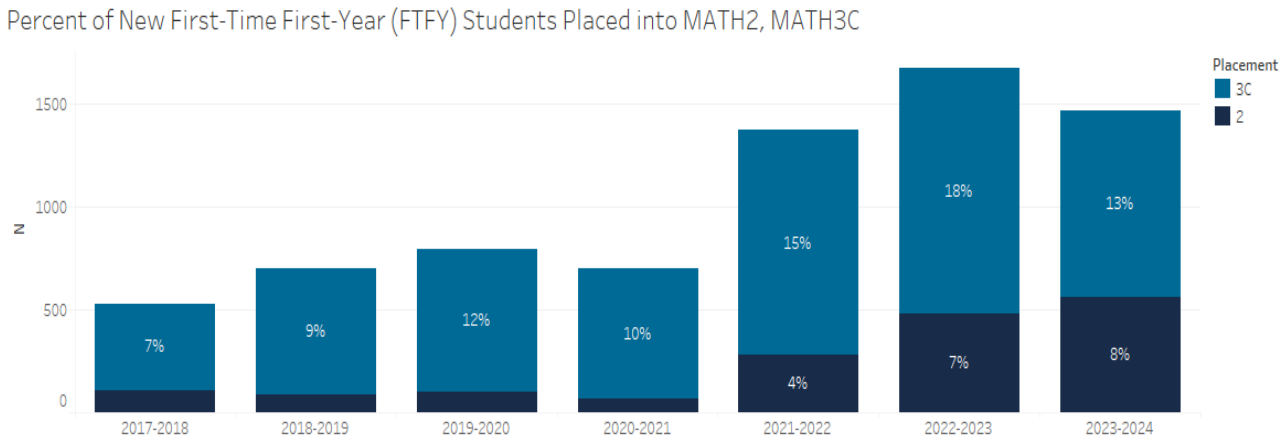

Figure 1

In addition to larger numbers in preparatory courses, the range of math preparation has expanded; students who place into Math 2 bring a variety of math skills (see Section 3). Possible reasons include that students admitted in 2021-22 completed high school during the pandemic and did not use standardized testing in admissions.

The workgroup charge focuses on equity gaps that are associated with disparities in math preparation and asks for potential campus interventions. While the charge does not ask for the source of these disparities, several workgroup members suggest that they are downstream effects that come from not identifying the mathematical preparation signal in admissions screening and/or a mismatch between a minimum math preparation and the Department of Mathematics' resources to address the problem from a curricular standpoint. There are also members who view equity gaps in math preparation as symptoms of structural racism that led to inequitable resources in K-12 systems that carry over to our campus.[2] Under this view, addressing them on our campus is an imperative. We acknowledge that math preparation is a complex issue that is largely beyond our direct sphere of influence. The Department of Mathematics has worked hard to serve increasingly heterogeneous cohorts – most seeking majors that require calculus. Much of the problem originates in the K-12 experience; we discuss this below, although it is beyond the workgroup's charge, which asks that we examine our own practices to support our students in achieving their goals. Any solution will be complex and bear on student support services, pedagogy, and curricula. Finally, while this report will not address possible sources of preparation differences, nor admissions, we note that a new Senate-Administration workgroup will focus on the admissions process and its implications for student preparation.

[2] Powell (2007:791) defines structural racism as emphasizing "the interaction of multiple institutions in an ongoing process of producing racialized outcomes." For example, the legacy of chattel slavery, followed by segregation, redlining, housing exclusion, among other overtly racist practices, have significantly contributed to inequities in educational opportunities which have, in turn, resulted in the equity gaps discussed here.

Powell, John A. "Structural racism: building upon the insights of John Calmore." *NCL Rev.* 86 (2007): 791.

2. Placement, Curriculum, and Pedagogy - Equity Gaps

The following diagram summarizes the calculus curriculum, along with paths that lead through the options. Again, the 10 series is calculus for Biological and Social Sciences, while the 20 series is for Physical Sciences, Mathematics, and Engineering:[3]

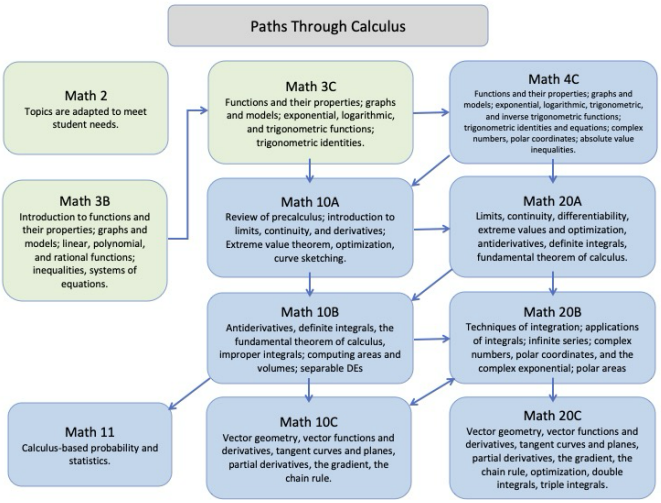

Figure 2

Math Testing and Placement, housed in the Department of Mathematics, administers two exams that help identify gaps in preparation and place students in this curriculum, although most students are placed into Math classes based on previous coursework. The Math Diagnostic Assessment is a largely formative tool that provides an adaptive diagnostic assessment of students' math preparation. It can assign early placement to either Math 10A or 20A, but, in addition, it provides feedback to students who do not place into calculus. Students can use this personalized feedback to address preparation gaps. If previous coursework or the diagnostic assessment does not place a student into calculus, they must then take the Math Placement Exam, which assigns placement into Math 2, 3B, 3C, 4C, 10A, or 20A (students place into 2 or 3B only based on a placement exam - never based on previous coursework). Students may repeat the placement exam every 30 days, although if taken remotely, they must pay the online proctoring fee after the first attempt.

While there is an automatic progression from Math 3C to 10A (and 4C to 20A), students who place into Math 2 must retake the placement exam to determine their subsequent level. This is because Math 2 has an adaptive curriculum - topics vary according to the students' preparation.

The workgroup was charged with discussing how disparities in math preparation and access to advanced high school or college-level math courses prior to attending the university contribute to disparities in math placement, which in turn contribute to equity gaps in retention and time to degree. Figures 3 and 4 show that retention and four-year graduation rates exhibit equity gaps

[3] Math 3B will be offered for the first time in 2024-25; this, as well as changes to the Math 2 curriculum, are discussed below.

when data are disaggregated by demographic categories, such as under-represented or first-generation status versus all students ('total'). The n-values and percentages are relative to the total number of students in each group (e.g., 2032, or 90.8% of the total number of under-represented students in the 2022 cohort were retained after one year). Also, note that those who do not graduate in four years include students who were not retained (in Figure 4, 1031, or 63.1% of under-represented students graduated in 4-years – the remainder were either not retained or took longer to graduate).[4]

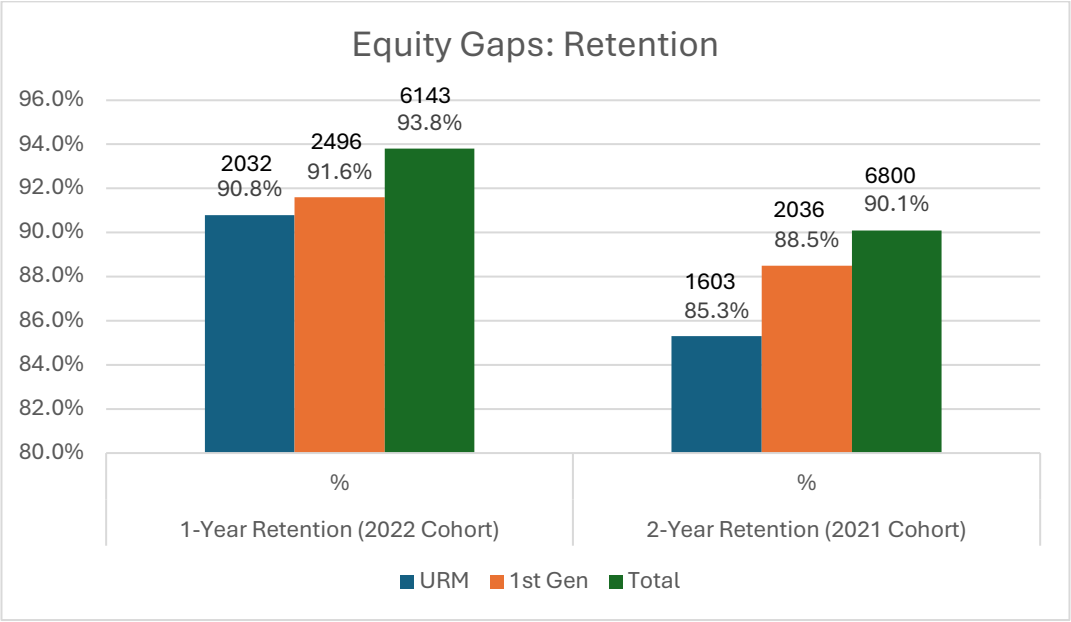

Figure 3

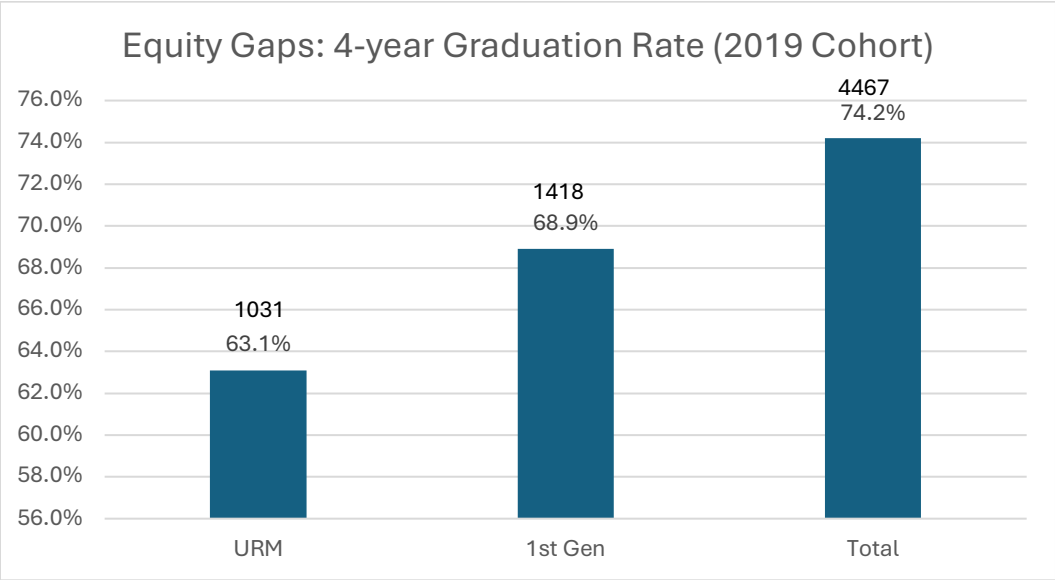

Figure 4

[4] For purposes of this report, 'under-represented' is as defined by the UC Office of the President and includes Black, Latinx, Native American/Alaska Native students.

There are differences in placement: under-represented and first-generation students place into preparatory math at a higher rate than others. The fraction of new first-time first-year domestic under-represented and first-generation students has ranged from 25% to 34% and from 27% to 42%, respectively, over the last seven years. The fraction of those students who place into Math 2 or 3C is much higher:

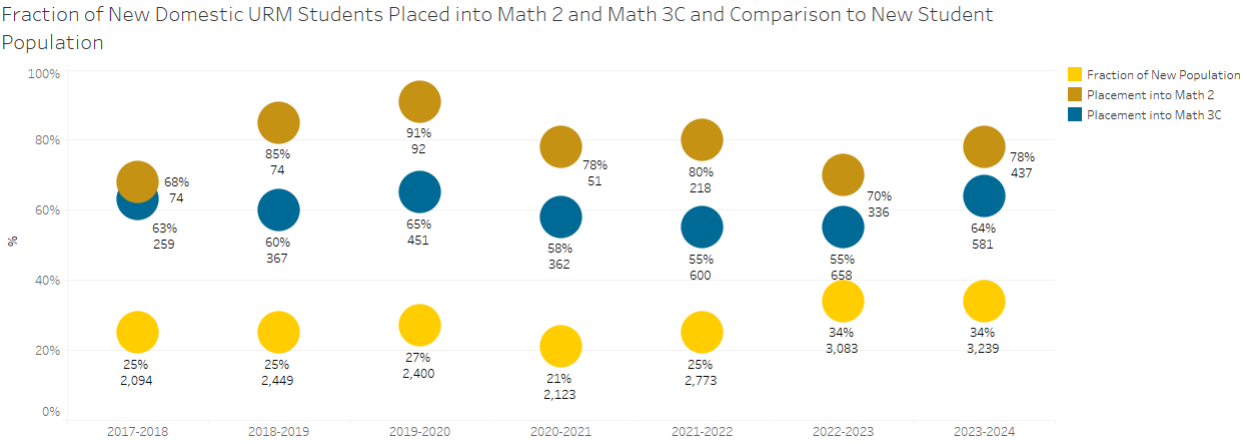

Figure 5

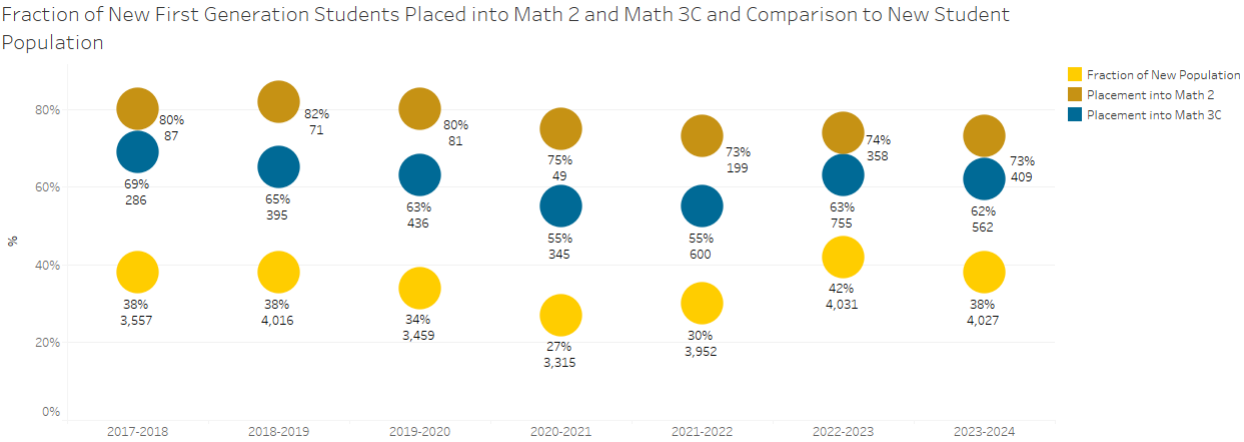

Figure 6

Figures 7 and 8 show trend lines associated with the Math 2 and 3C students in Figures 5 and 6. This preliminary analysis shows that the fraction of these students who are under-represented or first-generation has remained relatively constant even as the overall number of students starting in Math 2 has gone up. Thus, we do not see a (further) skewing of the these populations:

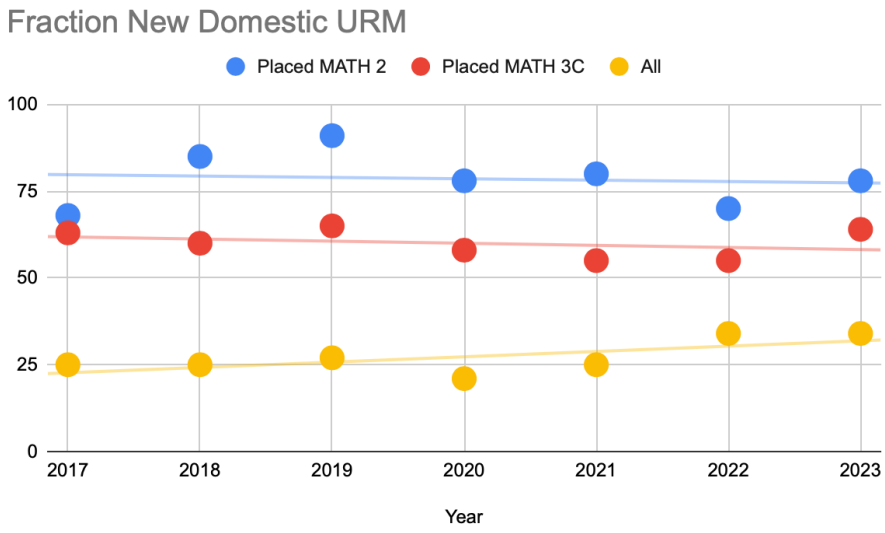

Figure 7

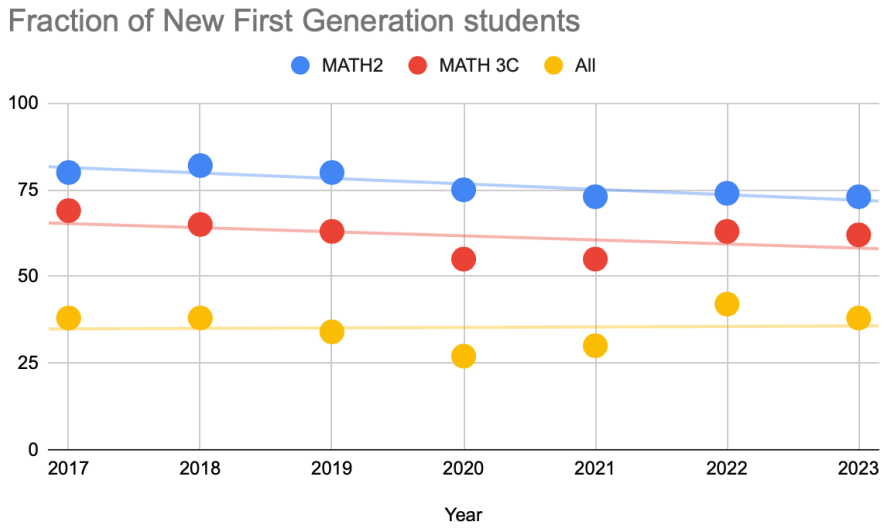

Figure 8

Focusing on gaps in retention rates, we can see a clear pattern between math placement and retention rates. For example, we see in Figures 9 and 10 that those who place in Math 2 or Math 3C have lower one- and two-year retention rates than those who place into the calculus series. Again, the n-values represent the reported percentage of students in each category:

Figure 9

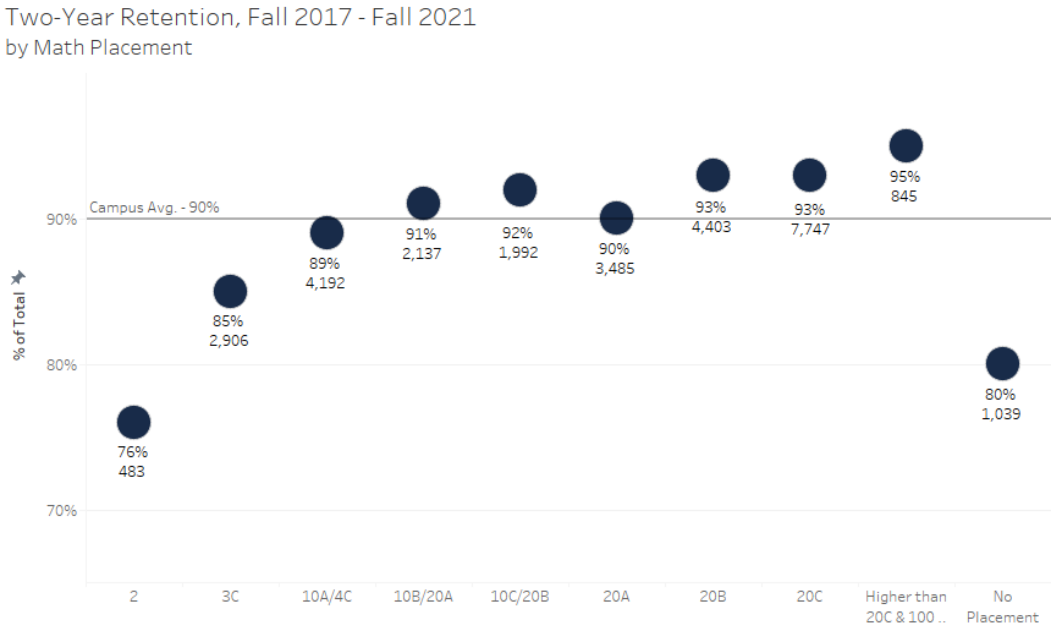

Figure 10

These gaps also vary depending on students' math requirements. The following illustrate different one- and two-year retention rates, depending on whether their initial declared major requires the10 or 20 series, makes math optional, or has no math requirement at all:[5]

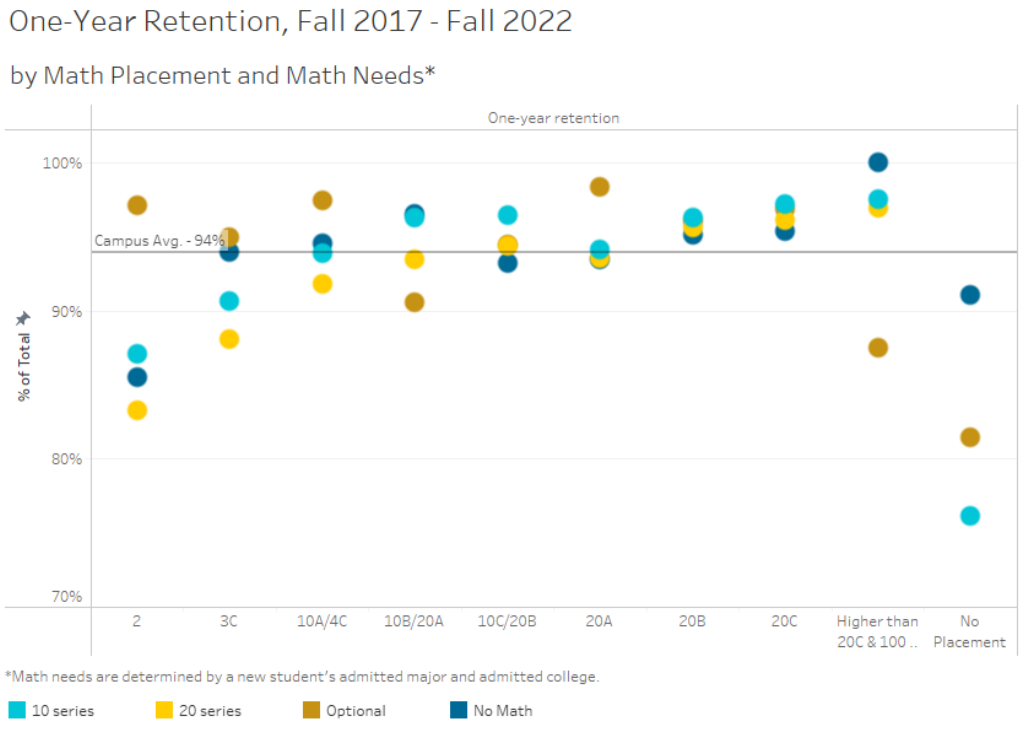

Figure 11

[5] Again, students with majors in Biological Sciences or some Social Sciences must take courses from the 10 series; those in Physical Sciences, Mathematics, and Engineering require the 20 series. The category 'optional' refers to students who have a quantitative general education requirement, for which they may choose a 10- or 20-series course, while 'no math' refers to those who do not need a math course.

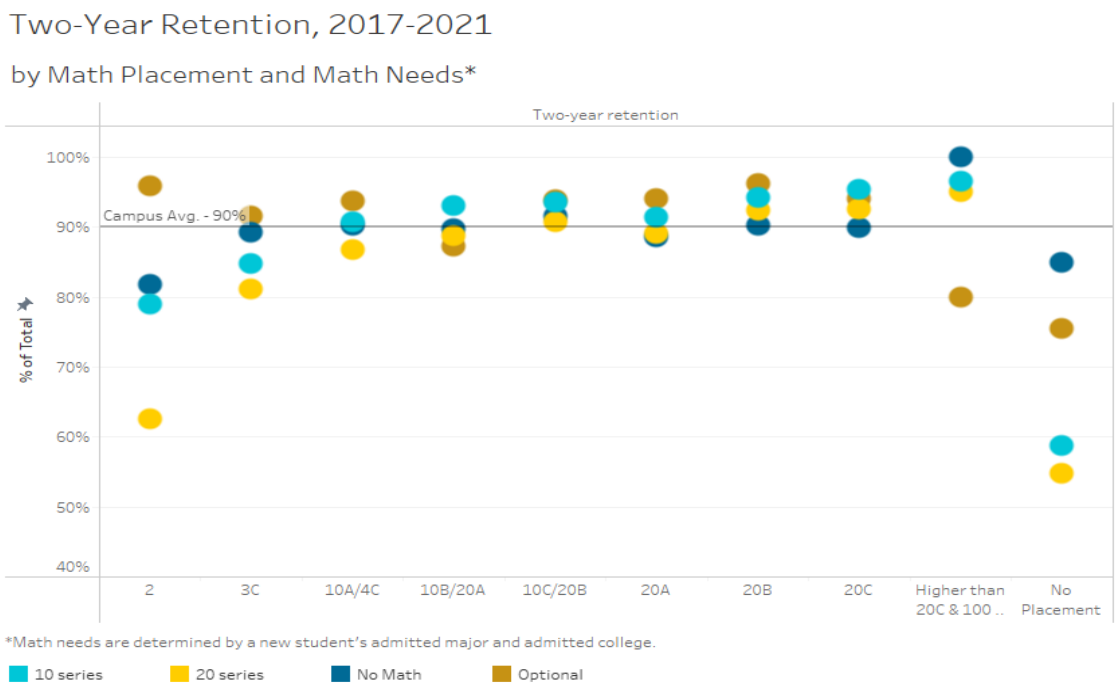

Figure 12

Figure 13 shows the four-year graduation rate for the Fall 2017–Fall 2019 cohorts according to initial placement. The figure shows that during this period, students who placed in courses such as Math 2 and Math 3C had a lower four-year graduation rate. Of course, those who do not graduate in four years include students who are not retained; hence, the numbers in Figures 9, 10, and 13 are not entirely independent. [6]

[6] As Figure 1 shows, Math 2 enrollment was relatively small and stable from 2017-18 to 2020-21 (averaging around 100 per year). Therefore, the four-year graduation rate in Figure 13 is from a small n-value (46% of 298 – the first three years that Math 2 was offered).

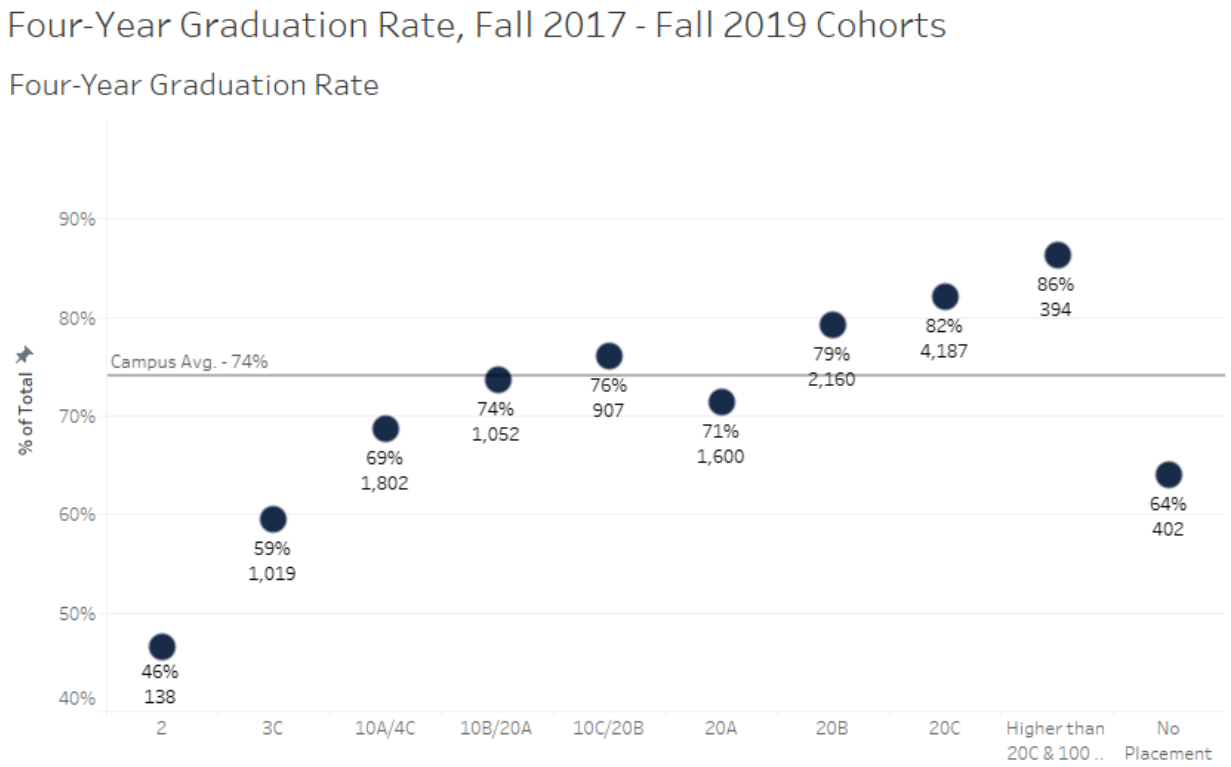

Figure 13

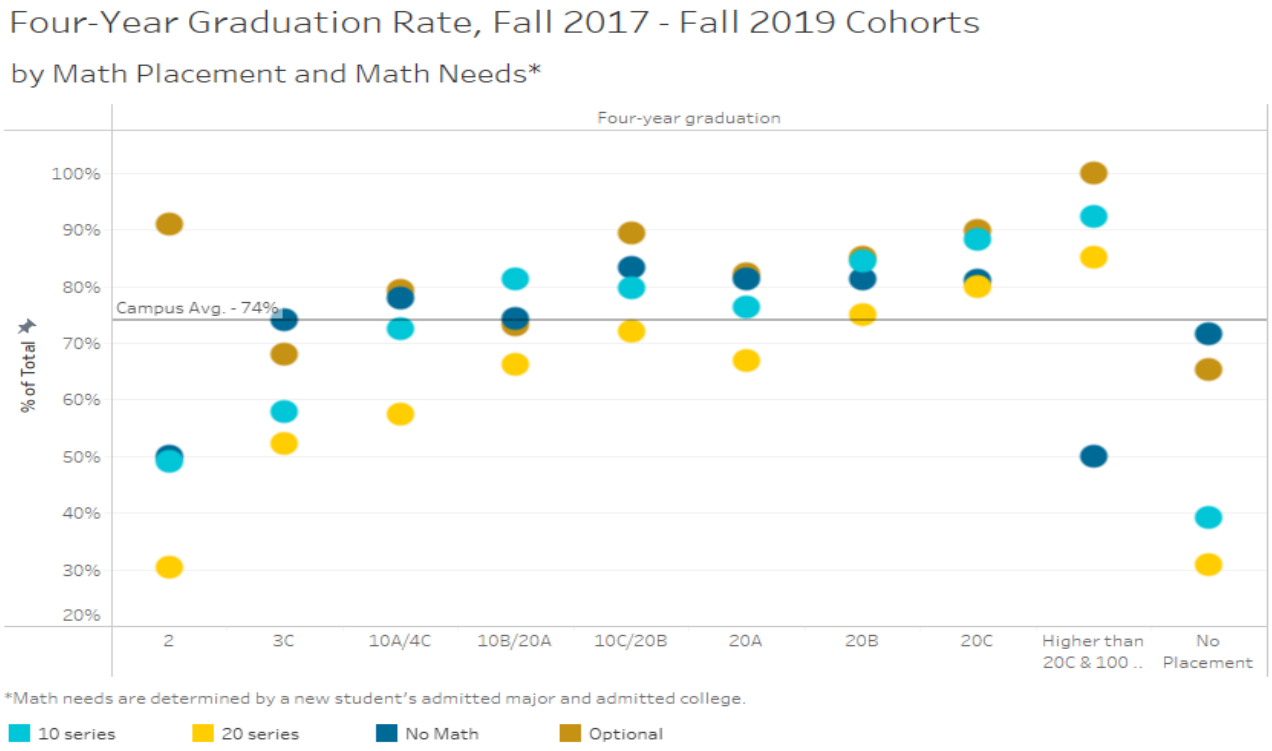

Figure 14

These data show trends between math placement on the one hand, and reduced retention rates and longer graduation times on the other. Students who place into Math 2 or Math 3C have lower retention and four-year graduation rates. Because under-represented and first-generation students place into Math 2 and 3C at higher rates than the campus average, retention and graduation rates may be disproportionately affected for these populations. It should be noted that, when reviewing these data, several workgroup members cautioned that one should be careful not to assume that placement into preparatory mathematics courses alone is the sole cause for reduced retention rates and longer graduation times and may instead be a signal that students need more overall academic support.

One obvious explanation for lower four-year graduation rates is that the poor high school preparation that necessitates taking courses that precede calculus (e.g., Math 2, 3B, and 3C) slows students' progress towards their degree. Calculus is often a prerequisite for major coursework; a delay in taking calculus may cause a delay in completing the major. Other factors must come into play to account for the retention gaps, however. It may be that placement into perceived remedial courses – while essential for providing the background needed to succeed in calculus – is demoralizing and has a negative impact on sense of belonging. Indeed, the UC Undergraduate Experience Survey (UCUES) does show that students who place into Math 2 have significantly lower scores than others on the 'I feel that I belong at UC San Diego' question (3.72 vs. 4.30, on a 6-point scale). However, we do not have sufficient evidence to suggest causation – Figure 5 shows a significant overlap between students who place in Math 2 and under-represented/first-generation students; these groups also score lower on this question.

Another factor may be downstream effects. For example, having to address significant math proficiency deficits (in material that should have been mastered in high school as part of UC's admission requirement C) in order to place into calculus, particularly given that acquiring these skills takes time, may result in incomplete mastery and academic difficulties in the calculus courses. Indeed, comparing students who place in Math 2 and 3C with those who place higher, we see that a Math 2 placement correlates with higher DFW rates in subsequent classes, while a Math 3C placement is associated with higher DFW rates in the 20 series:

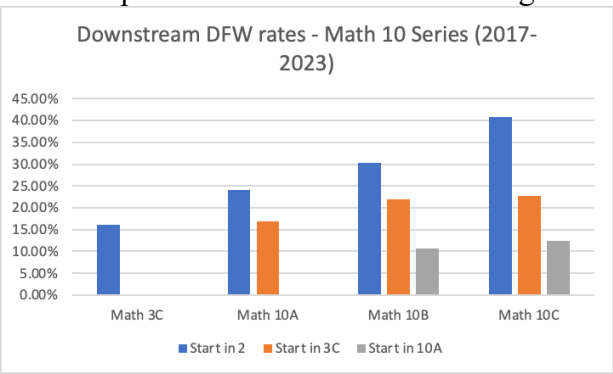

Figure 15

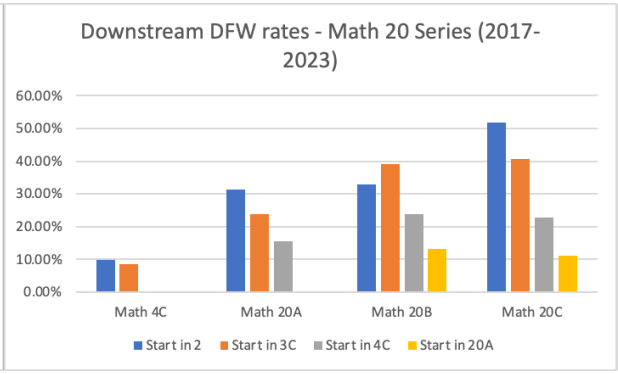

Figure 16

While those who initially place into Math 2 have a relatively high DFW rate in the Math 10 series (10A: 24.1%, 10B: 30.3%, and 10C: 40.7%); these percentages are noticeably higher than those who place into 10A (where DFW rates are close to the STEM average of around 10%). The 10B DFW rate is worrisome, since this is the final calculus course required for Psychology

BS and most Biology majors. The numbers are even more worrisome in the 20 series – nearly a third (31.2%) of students with Math 2 placement and needing the 20 series are unsuccessful initially and over half (51.8%) do not pass Math 20C; however the number of students who place into Math 2 and subsequently take Math 20 courses is small compared to those who take Math 10 courses (203 versus 1207, over the seven year period). [7]

The data on persistence in the major are somewhat different. We see a small increase in changes among students who place in Math 2 and are in majors that do not require calculus. The persistence in the original major is actually higher for Math 2-placed students than others. There is a good deal of movement – both to majors that require the 10 series and those that require the 20 series, and some inter-group differences, but it is hard to conclude that a lower initial math placement has a significant effect on persistence in the major (Figures 17 and 18 do not include students who either complete the major or are not retained):

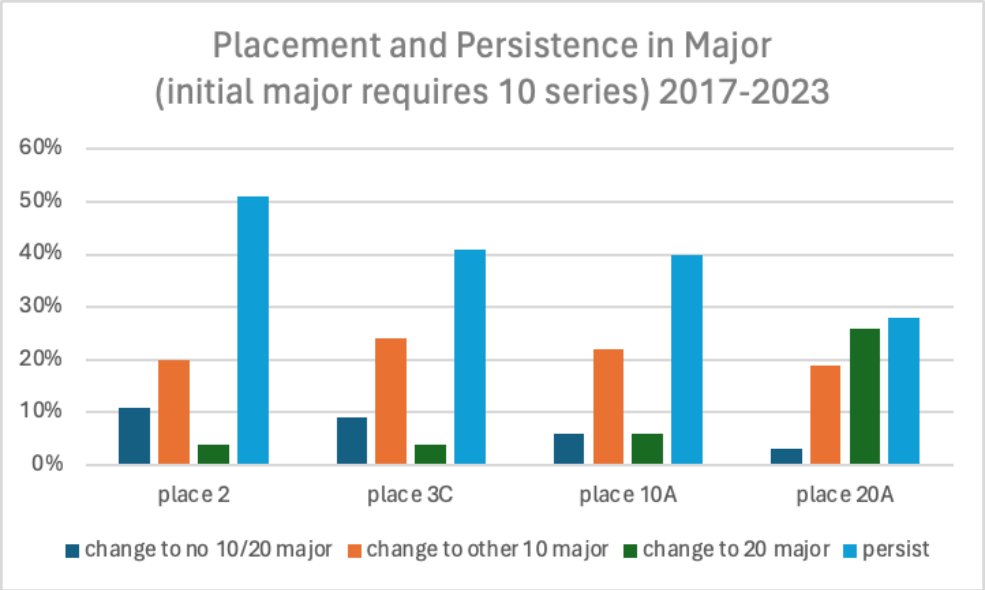

Figure 17

[7] In Fall 2024, enrollment in Math 2 broke down as follows: 300 from Math 10 majors, 94 from math 20 majors, and 79 from majors that did not require calculus. Thus, while 10.3% of all new Math 10-major students placed in Math 2, only 3.4% of all new Math 20-major students did so. Some Math 20-major students who start in Math 2 switch to a non-math-20 major before they get to Math 20C or drop out.

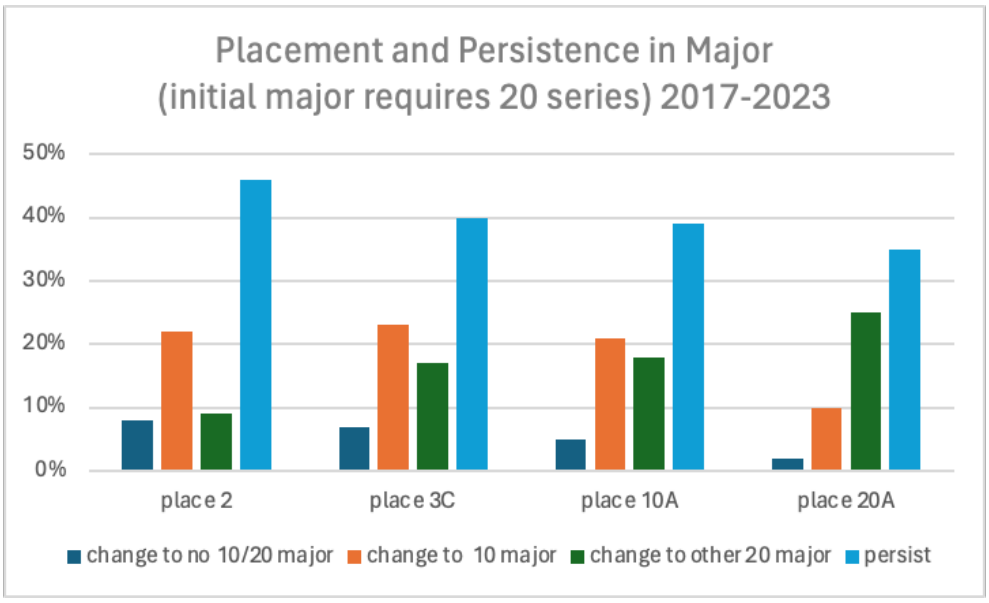

Figure 18

Of course, persistence in a major does not necessarily entail success in the major. The time lag between entering cohort and eventual graduation makes it difficult to see how many of these students will eventually graduate and in which majors. We do know, however, that the five-year graduation rates for students placed in Math 2 or 3C are well below the campus average (based on 2017 and 2018 cohorts, but, again, with a small n-value for Math 2 students):

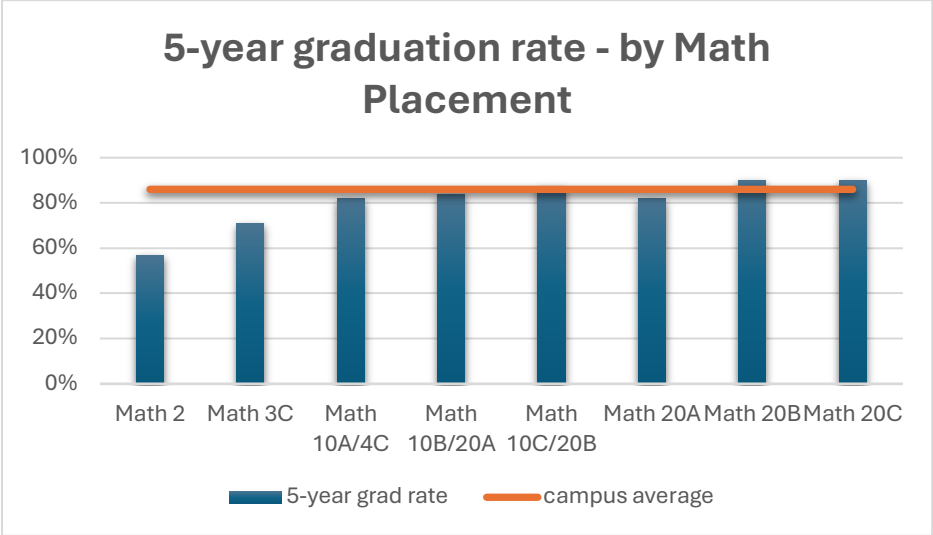

Figure 19

We only have six-year graduation rates for the 2017-18 cohort; there we see decreased graduation rates for those who placed into Math 2 (59%, but again, with a small n-value) and Math 3C (74%); those who placed into 4C or the calculus series had rates on par with or exceeding the campus average of 88%.

The workgroup charge asks how our approach to testing, placement, and curricular structure might contribute to equity gaps. We have seen above how students who take Math 2 or 3C have lower four-year graduation and retention rates. This is largely a function of how student preparation interacts with our placement mechanisms and curricula. Initial preparation is based on K-12 experiences; the question is how our campus might change practices around testing, placement, pedagogy, and curriculum to help students succeed, building on the assets they bring and providing support where there are gaps in preparation.

Discussions in the workgroup underscored the complexity of the problem; furthermore, there was not always agreement. The following tries to provide a sense of the discussions.

Placement. The use of the Math Diagnostic Assessment, followed by the Math Placement Exam has proven to provide a reliable assessment of math preparation, leading to accurate placement. Given the consequential nature of the Math Placement Exam, it does represent high stakes. While there is literature that suggests that some student demographics are disproportionately impacted by high stakes exams,[8] the recent change that allows students to retake the exam after 30 days may lessen pressure. The Mathematics Department conducts quarterly reviews of the efficacy of the Math Placement Exam and other placement measures; we recommend that they continue their evaluation processes and make data-driven adjustments to established metrics and procedures.

Programming in Summer Bridge helps students develop math confidence and test-taking strategies that mitigate negative effects; these efforts should be supported and potentially expanded (see below).

Curriculum. There is now a potential one-year sequence of preparatory math. A student, placing into Math 2, might go on to 3B, then 3C, before enrolling in calculus. In practice, students might skip one or more steps or might take even longer. Clearly, an extra year before entering major coursework may affect time to degree. We have seen that placement into remedial courses is

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[8] High stake assessment: Assessments with important consequences for test takers, on the basis of their performance. Passing has important benefits, such as progressing to a higher grade, a high school diploma, a scholarship, entrance into the labor market or getting a license to practice a profession. Failing also has consequences, such as being forced to take remedial classes or not being able to practice a profession. Examples of high-stakes tests include college entrance examinations, high/secondary school exit examinations, and professional licensing examinations." (International Institute for Educational Planning (IIEP) Learning Portal, UNESCO)

Literature on high-stakes testing includes:

Cotner, S., & Ballen, C. J. Can mixed assessment methods make biology classes more equitable? *PLoS one, 12*(12) (2017).

French, S., Dickerson, A. & Mulder, R.A. A review of the benefits and drawbacks of high-stakes final examinations in higher education. High Educ 88, 893–918 (2024).

Heissel, Jennifer A., et. al. Testing, Stress, and Performance: How Students Respond Physiologically to High-Stakes Testing. Education Finance and Policy16 (2),183–208 (2021).

Ralph, V. R., Scharlott, L. J., Schafer, A. G. L., Deshaye, M. Y., Becker, N. M., & Stowe, R. L. Advancing Equity in STEM: The Impact Assessment Design Has on Who Succeeds in Undergraduate Introductory Chemistry. JACS Au, 2(8), 1869-1880 (2022).

associated with lower retention and negative downstream effects. However, discussions in the workgroup emphasized that acquisition of math skills takes time – there is no real way that students can move on without having room to develop a firm foundation. Thus, there is a conundrum: the long sequence corresponds to lower retention and may increase time to degree, but there is no realistic alternative. There was discussion of co-requisite models, but it was not clear how effective these have been, particularly when the preparation is at the Math 2 level and given our large class sizes. Nonetheless, this trade-off might be explored further.

Another area to explore is whether calculus is necessary in all the majors that require it. Ideally, this should be determined by mapping calculus learning outcomes to prerequisite structures. It may turn out that some majors might eliminate or reduce calculus requirements; it may also be that the division of the 10 and 20 curricula are not always aligned with disciplinary needs. Because calculus can present a barrier for student success and the 20 series is particularly challenging for many students, we should ensure that requirements are justified on the grounds of learning outcomes. Note that this is not intended to reduce rigor in the majors – each academic unit determines which skills are required for their fields of inquiry - but we should only require courses that are actually needed in the discipline.

In cases where calculus is required, we might look at the four-year plans to determine where it is best situated in the curriculum. In some cases, it may turn out that learning outcomes are not needed until the third year – in that case, the timing of the sequence can be adjusted to allow for a year of preparatory work. This would give students who are placed into earlier classes an on-ramp that does not delay their ability to enter other major coursework. Departments that, after evaluation, need calculus learning outcomes are encouraged to use curricular analytics tools to provide students with multiple recommendations on pathways they can follow to acquire the required calculus background.

Faculty in disciplines that require calculus report that students often have difficulty in transferring their math concepts to the major subject matter. Because calculus is taught as Mathematics courses, the material tends to be theoretical. There are a number of possible ways to address this – e.g., creating courses tailored to specific disciplines (Calculus for Physics, for Chemistry, etc.) or having discipline-specific discussion sections, where exercises are drawn from the area in question. There are logistical challenges in staffing and scheduling these, but perhaps some of this could be piloted.[9]

Pedagogy. UC San Diego's Department of Mathematics has the most Math majors in the country. In addition, the calculus curriculum, including the preparatory courses, serve most of our undergraduates – from all STEM and many Social Science majors. Therefore, the teaching needs are immense. Courses are taught by a combination of Senate faculty (ladder-rank and teaching professors), Unit-18 Lecturers, and Postdocs. This creates challenges in implementing consistent curricula and pedagogical practices. The following shows the range of variation in

[9] The Mathematics Department at UC Santa Cruz is redesigning its Calculus with Applications sequence (Math 11) for life sciences students. Without modifying learning outcomes, they are adapting the questions to include relevant biological context. Funded by a Graduating and Advancing New American Scholars (GANAS) grant, they employ graduate student researchers to help develop the discipline specific content.

DFW rates in Math 2, 3C, 10A, and 20A for all instructors the 2023-2024 academic year (excluding Summer Session):

DFW 23-24	Math 2	Math 3C	Math 10A	Math 20A
Min	8%	14%	5%	8%
25th %ile	25%	19%	7%	12%
Median	33%	30%	12%	13%
75th %ile	43%	36%	13%	21%
Max	47%	40%	14%	40%
Variance	0.0150	0.009067	0.001181	0.011425
Std. Dev.	12%	10%	3%	13%
Std. Error	1.36%	1.59%	0.57%	1.78%

Figure 20

Given the range of preparation among students placed in Math 2, we expect higher variation in DFW rates; indeed, this is borne out in the 8-47% range, relatively high median, and large standard deviation. Students who successfully make it to the calculus series (either through initial placement or by taking preparatory courses), should show less variation – this is true for Math 10A, but not 20A. The variation associated with Math 3C falls in between Math2/20A and 10A. Of course, many factors go into grading besides curriculum and pedagogy; we should not assume that a higher DFW in a particular section is the result of poor teaching, nor that a low one is the result of good teaching. Nor can we conclude that one suggests more or less rigor than the others. Nonetheless, we should strive for standardization in curricula and consistent pedagogy. To this end, we recommend working to standardize curricula and pedagogy, partnering with the Teaching + Learning Commons and potentially making use of the features of the Prairie Learn software (currently piloted via computer testing). Such a partnership can be facilitated through a Memorandum of Understanding.

In addition, the National Academies of Sciences, Engineering, and Medicine recently released a report *Equitable and Effective Teaching in Undergraduate STEM Education: A Framework for Institutions, Educators and Disciplines* that uses research on learning to propose principles for equitable and effective undergraduate STEM education. Many of their recommendations – particularly around serving an increasingly diverse student population - are relevant to the charge of this workgroup; we recommend that the campus critically discuss this report.

Advising. It is clear from this report that students who place into Math 2 have a potentially long and difficult road to complete the calculus required by their majors. The same is true – to a lesser extent – for students who place into Math 3C (we have no data for 3B yet). Students in these preparatory classes will benefit from proactive advising to ensure that they know how to stay on track for their academic goals and understand the requirements of their majors. Advising conversations might include some of the following:

- Alternative academic plans, given their initial math placement
- Connection to academic support resources
- Discussion of alternative majors

This last point has to be done very carefully; the advising community might partner with OASIS, the Teaching + Learning Commons, and the resource centers to ensure appropriately supportive conversations.

The nature of advising must be tailored to the student's major. Figure 21 shows that 44% of all students who placed in Math 2 (2021-2023) were initially in Biology and Psychology majors:

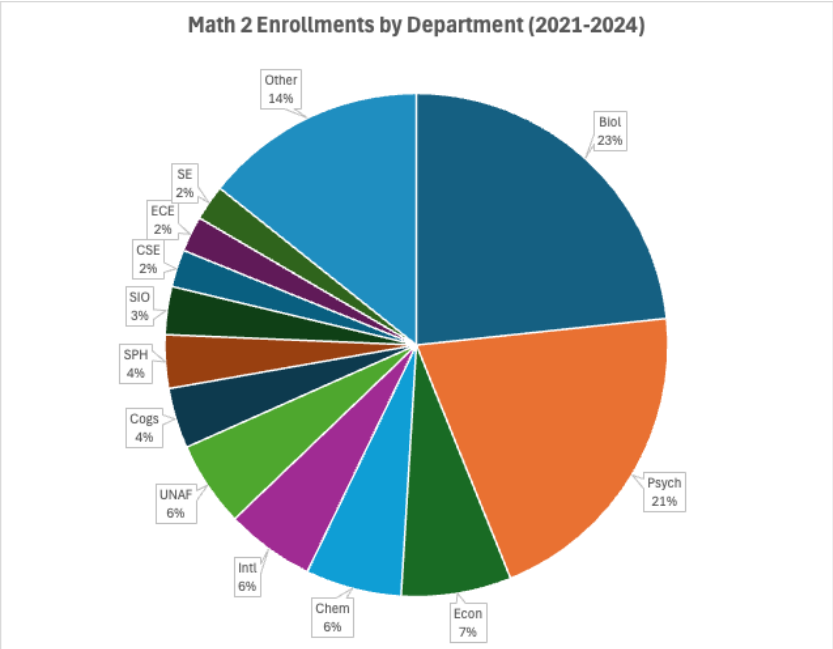

Figure 21

Most Biology majors require Math 10A, 10B, and 11; these students will need to get to calculus, but perhaps their four-year plan can be structured to allow for the preparatory classes (although this is complicated by a CHEM 6A prerequisite). Psychology students in the BA major only need statistics – they might be advised to take a statistics course that does not require calculus – e.g., Psych 60 (of course, they will need sufficient math preparation for that course). Psychology students in a BS major should understand the timeline for completing the calculus requirement and trade-offs between the BS and BA majors.

Finally, it may be that students who struggle in mathematics also struggle in other areas. The future workgroup on admissions will be charged with examining both math and writing preparation, but the question is surely broader than these two areas. Advisors are in a unique position to view students holistically and connect them to resources.

3. Preparatory Courses and Support Programs

The Workgroup charge asks how effective our current preparatory curriculum and support programs have been in addressing equity gaps. This section examines the current preparatory

courses – Math 2 and 3C – as well as recent revisions to the preparatory curriculum.[10] It then discusses support programs in the Teaching + Learning Commons, OASIS, and Summer Bridge.

Math 2

Math 2 was established in 2016 after college deans of academic advising noticed a decline in quantitative SAT scores in the incoming first-year class. It was intended to be a small and adaptive course to help students who were not ready for precalculus. As a remedial course, it offers 4-units of workload credit, but no baccalaureate credit. Students who pass Math 2 do not automatically go on to 3C; rather, they take the Math Placement exam to determine the next course. As shown in Figure 1, between 1-2% of the first-year class placed into Math 2, up until Fall 2021, when the percentage began a rapid increase (4, 7, and 8% between 2021 and 2023). With this increase in demand, the original conception behind this course became untenable:

- With 559 students placing in Math 2 in Fall 2023, the small class model was not sustainable.
- Math 2 was originally designed to cover math skills from grades 9-10; however, in recent years the range of preparation increased dramatically, with the range of math skills spanning about eight years. In Fall 2023, a math preparation assessment was administered to about 140 students enrolled in Math 2. The assessment was based on Common Core standards for grades 1-8. It found that among the Math 2 students assessed, 20% failed on grade 2 level problems and less than 20% correctly answered problems at a grade 8 level. On average, the student performance declined 8.5% per grade level problem type. With an average score of 59%, the mean was around a grade 4-6 level. Students were particularly weak on multi-step problems and those involving fractions, decimals, percentages, and shapes.

Math 2 has a high DFW rate (average 31% between Fall 2021 and Spring 2024, excluding Summer Session). Furthermore, as shown in Figures 15 and 16, students who initially place into Math 2 have high downstream DFW rates.

In response to these issues, the Department of Mathematics is revising the Math 2 curriculum dramatically; the new format will begin in Fall 2024 to address the challenge of large numbers of students with disparate preparations by a combination of large fixed-content lectures and individualized lab sessions. The latter are facilitated by undergraduate and graduate learning assistants. Students will complete assignments determined by the ALEKS software – an adaptive learning tool. The course will continue to offer workload credit only, but will now be P/NP – the grading system uses a combination of class attendance, signing up for and attending time slots at ASC@Math, and written homework (graded for on-time submission, following a Style Guide, and making an effort). After passing Math 2, students will still take the Math Placement Exam to determine their next course.

The hope is that this model, in addition to being scalable to larger enrollments, will both standardize the Math 2 curriculum, while allowing for individualized needs. The course itself will be low-stakes – a P grade is available to anyone who earns 70% of the points available in

[10] We don't discuss Math 4C – the pre-calculus course that feeds the 20 series.

the three categories detailed above, but should provide students with the necessary skills to progress through the curriculum. It will be important for the Math Department to continue to monitor outcomes.

Because not all students who place into Math 2 have the same preparation level, we need to examine factors other than post-Math 2 placement in evaluating effectiveness. That is, outcome measures should not assume that all students start at the same level. This is particularly important when disaggregating data along demographic lines. If, for example, due to societal inequities, a large percentage of the least prepared students are under-represented, then we would expect lower grades/pass rates for this group not because of their under-represented status nor ability to learn, but rather, because they started with less preparation. To help eliminate this confounding variable, future analysis could examine growth on the Math Placement Exam scores (before and after Math 2, disaggregated) as a measure of how our curriculum impacts equity gaps. The Mathematics Department might partner with the Office of Educational Innovation on this – this would require resources, however.

Math 3C

Math 3C is the pre-calculus course; it offers baccalaureate credit. Students place into this in a variety of ways – e.g., AP scores and the Math Placement Exam. A passing grade in Math 3C allows students to move into 10A. Again, there is no automatic transition from Math 2 to 3C – Math 2 students must place into Math 3C though the placement exam.

Figures 15 and 16 shows that students with initial Math 3C placements usually show a better downstream performance than those who first place into Math 2. Nonetheless, the DFW rates remain high: the average in 3C itself between Fall 2021 and Spring 2024 is 16%; downstream DFW rates in 10A, 10B, and 10C are 16.8%, 22%, and 22.8%, respectively (cumulative between 2017 and 2023). Looking at data from 2017 to 2020, The Department of Mathematics noted high DFW rates in 3C when students' Math Placement Exam scores were on the low end of the 18-33 point spectrum (the scores that determine a Math 3C placement). In addition, students with these scores who did pass 3C were more likely to later fail 10A.

In response, and because of the range of variation found in Math 2 student preparation (see above), a new course – Math 3B – has been approved and began in Fall 2024. This class targets students who place at the high end of the Math 2 and low end of the Math 3C spectra. It covers topics that overlap what might be currently found in Math 2 and Math 3C. The idea is that this will set students up to be more successful in Math 3C and, later, in the calculus series. Math 3B does offer baccalaureate credit and a passing grade allows students to move on to 3C (without a placement exam) or to calculus (with a placement exam). Creating yet another precalculus course potentially extends the number of courses some students will need before enrolling in calculus. One could imagine a full year of coursework: 2-3B-3C (and then, potentially 4C, if the student needs the 20 series). However, this extra quarter may actually save time for many students who place into Math 3C and then fail or barely pass and then fail 10A. It will be important to assess these trade-offs; indeed, the Academic Senate, in approving 3B, asks for data on its effectiveness five years from now.

While creating a longer chain of courses that precede calculus may extend the time it takes students to enter into major coursework. These courses have the potential to afford the time that may be necessary for students to acquire the learning outcomes.

Supplemental Instruction and Tutoring

Academic support – in the form of supplemental instruction, content tutoring, and workshops – has been offered in the Teaching + Learning Commons, OASIS, and through Mathematics TAs, as well as in other departments. The goal is to provide support for historically difficult courses – those with large enrollments, high DFW rates, and high-stakes assessments, among other factors.

Supplemental Instruction sessions offer students the opportunity to master course material within a community of learners. This program gives students an environment to engage with content, ask questions, and review lecture material with their peers.

Supplemental Instruction sessions are facilitated by peer leaders (known as SI Leaders) who have successfully completed the course they were recruited for at UC San Diego. These leaders are trained in facilitating sessions that encourage students to work together to learn the course material.

- Sessions meet weekly for 80 minutes
- Sessions are offered in a hybrid model, with in-person and virtual sessions offered.

In the 2023-2024 academic year, the Supplemental Instruction program served about 8,500 students. Program assessment demonstrates that those who participate in Supplemental Instruction obtain grades a half-letter higher than those of peers who do not participate.

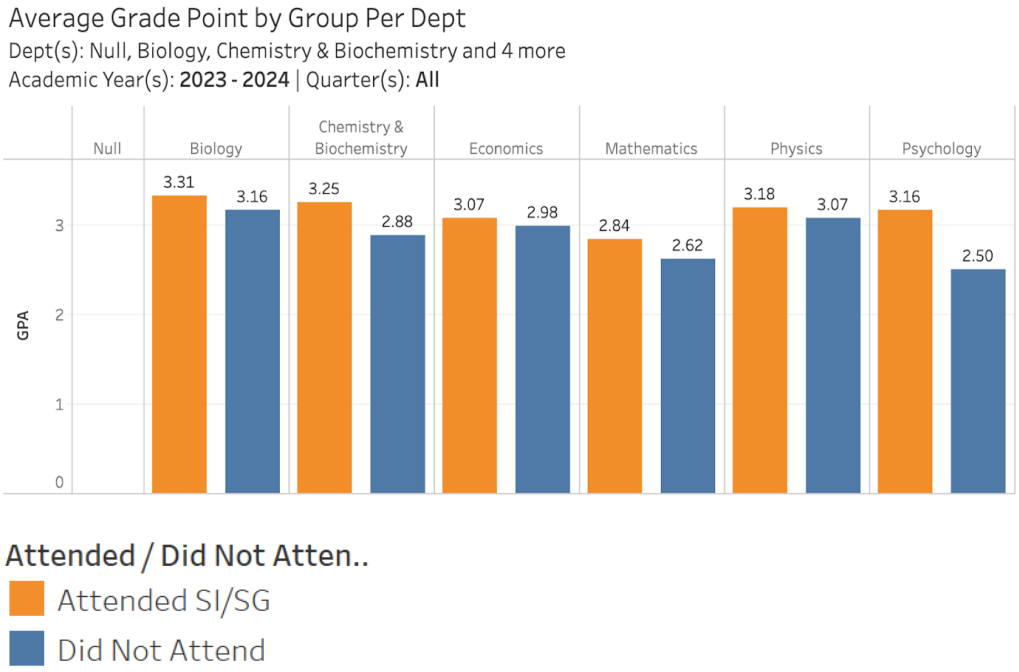

Figure 22

We also see that the number of students who drop, fail or withdraw (DFW) from the course decreases for students who attend supplemental instruction, compared to those who do not:

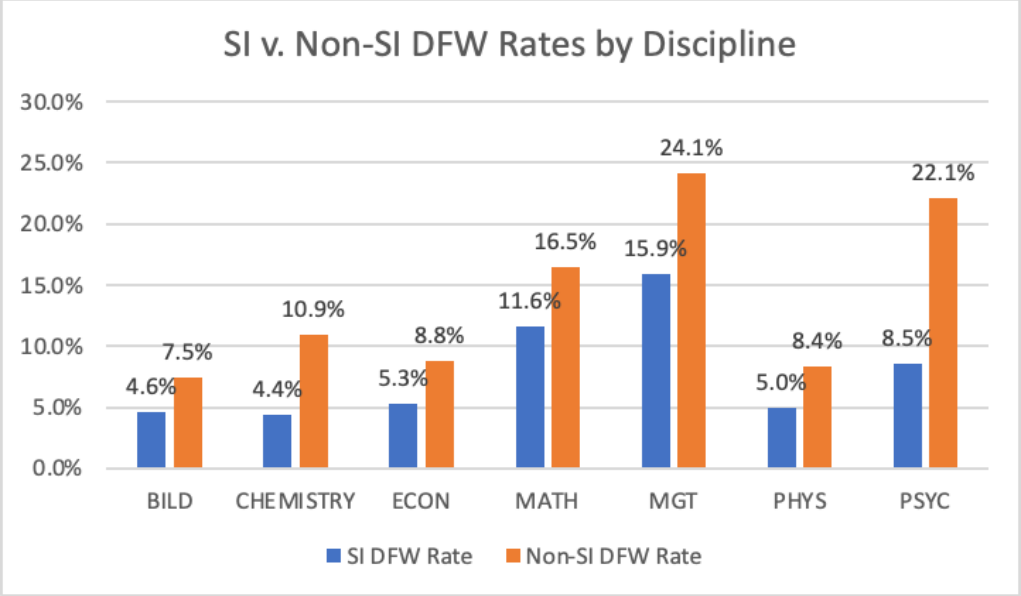

Figure 23

While selection bias may play a role in the above data (Figures 24 and 25), it does show that participating in supplemental instruction is associated with higher GPAs and lower DFW rates. Figure 26 shows that while all 2023-24 who attended 5-9 supplemental instruction sessions saw decreased DFW rates, students who are under-represented and/or first-generation show larger gains:

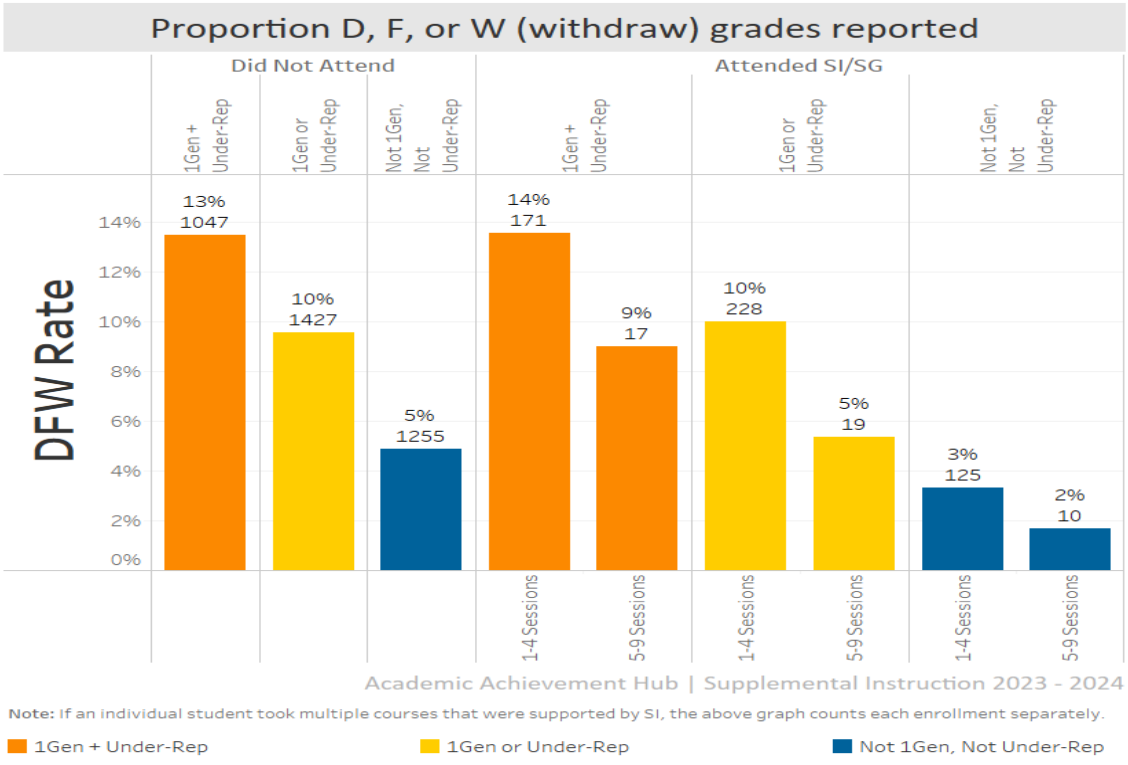

Figure 24

The Commons currently offers supplemental instruction to all of the courses in Figure 8 (except 3B, because it was introduced after the others and there are no resources to support it). In addition, the Commons offers content tutoring in many of these same courses; this peer-tutoring program employs students who have excelled in the courses and trained to build community with their students.

The OASIS Math & Science Tutorial Program offers both tutoring and workshops – the latter are transitioning to a supplemental instruction model. There is currently significant overlap between the academic support provided by the Commons and OASIS. Finally, the Department of Mathematics employs TAs and peer tutors for their courses.

Because of limited resources and high staff turnover, the Commons, OASIS, and the Department of Mathematics have had conversations about math pedagogy and more efficient allocation of academic support resources. Beginning in 2024-25, OASIS began to support students enrolled in preparatory math courses, while the Commons continues to support students in the calculus series. All parties use a common training model for peer educators. Math faculty can receive pedagogical support for courses that receive academic support.

In addition, both the Commons and OASIS offer study sessions for the Math Placement Exam for students who place in Math 2. These sessions provide a valuable opportunity for students to practice the language and pace of the exam, review and reinforce material, and develop test-taking skills.

Summer Bridge – Accelerate to Calculus

The UC San Diego Summer Bridge program is a year-long program focused on supporting historically under-represented, including historically minoritized, first-generation, and low-income students, through their transition from high school to college. The program kicks off with a five-week experience, either in-person or virtually, where students can earn up to 8 units of college credit while developing academic skills and gaining knowledge, confidence, and a strong sense of belonging within the UC San Diego community. Over the last five years, the Summer Bridge program has experienced exponential growth - from 283 students in 2019 to 711 students in 2023. The program's goals are to help students in:

- Acclimating to the academic culture of UC San Diego
- Discovering UC San Diego's robust community of support for all students
- Building a strong network of peers and mentors
- Easing the exciting transition from high school to college

Despite its name, Summer Bridge is a year-long program; participants begin in a five-week summer program and continue to participate through learning communities during their first year.

Students enrolled in Bridge have been offered Math courses, according to their placement exam results; these typically include Math 2, 3C, and 10A. Students who place into Math 2 have had two options: a traditional Math 2 course (adaptive content, taught remotely) or the Accelerate to Calculus program. The goals of the latter are:

- Address the disproportionate number of first-generation and low-income students who place into Math 2
- Provide low stakes alternatives to advance in math pathways
- Take a collaborative approach to improve self-efficacy and math confidence
- Offer an alternative to Math 2 (because of limited enrollment capacity)
- Strengthen students' mathematical resilience
- Review and reinforce essential precalculus topics, including algebra, trigonometry, and functions
- Develop problem solving strategies, analytical skills, and critical thinking necessary for success in Calculus and subsequent mathematics courses
- Cultivate mathematical confidence and foster a growth mindset attitude towards mathematics
- Feed into follow-up learning communities and study sessions in the Fall

The Accelerate to Calculus program focuses on infusing culturally responsive teaching practices into the curriculum. The faculty connects mathematical concepts to the cultural experiences and knowledge of the students in the course. Despite not having workload credit nor grades, the Accelerate program performed on par with the Summer Bridge 2023 Math 2 course in terms of successful placement into 3C (Summer Bridge Math 2 – 61%; Accelerate – 62%). The n-values in the Accelerate program are very small, however.

Figure 25 shows the DFW rates in Math 3C for students who took Math 2. Bridge students, who took Math 2 in the summer, are compared with all students who took Math 2 (in summer or F-W-S of the designated academic year). Students from both groups took Math 3C in F-W-S of the designated academic year. Summer Bridge students who took Math 2 in the summers of 2021 and 2022 performed nearly on par with all students. However, the 2023 Bridge students had a much higher DFW rate than all students in their downstream Math 3C course:

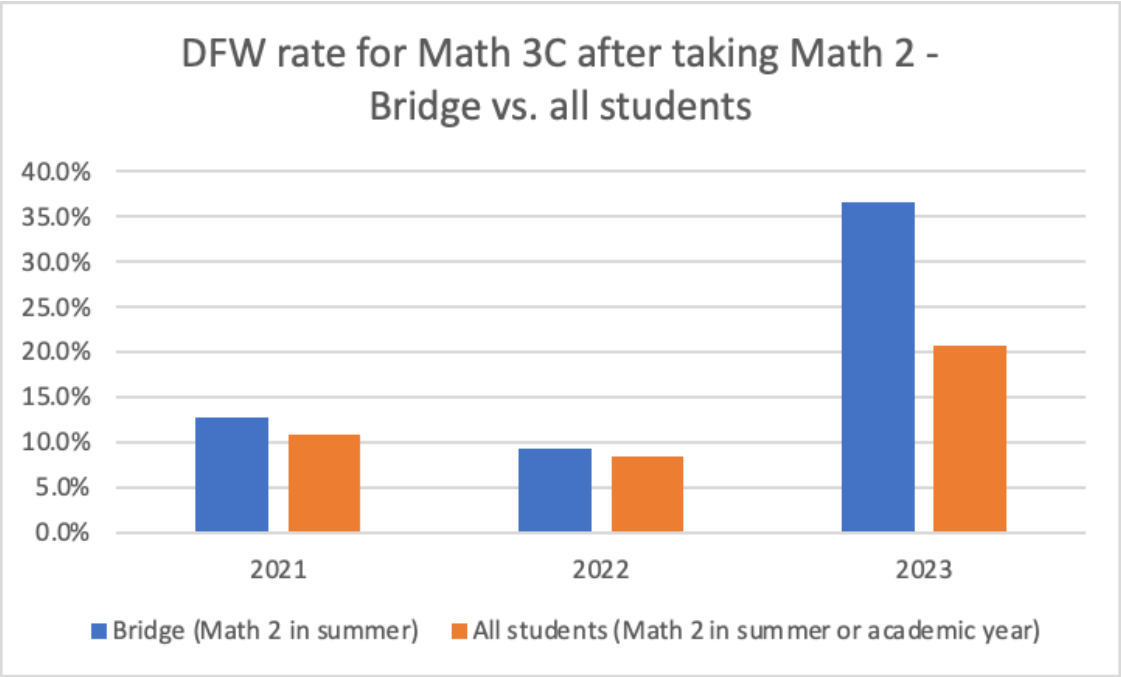

Figure 25

It may be notable that 2023 saw a sharp increase in the number of students placed into Math 2 (see Figure 1). It is possible that these 2023 Math 2 students began to show more variation in preparation and that the compressed summer offering was not sufficient to provide the necessary background for success. Nonetheless, it is unclear why these students successfully placed into 3C, only to fail at such a high rate.

Figure 26 looks at DFW rates in Math 10A, comparing Bridge students who took Math 3C in the summer with all students who took 3C (either in summer or the academic year). The 2021 and 2022 cohorts experienced relatively high DFW rates; these rates did improve with the 2023 cohort:

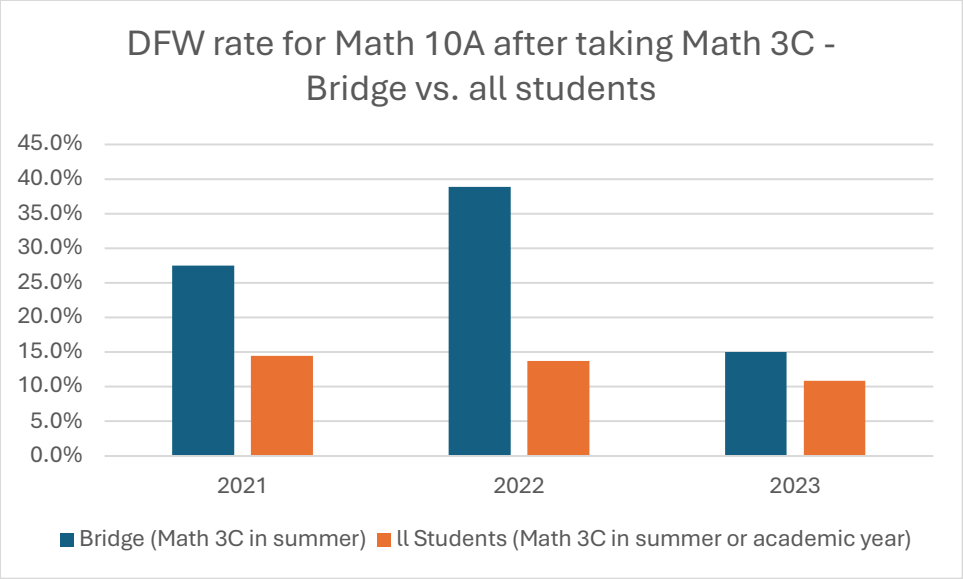

Figure 26

These data are relevant to a number of conversations within the workgroup and Summer Bridge. Mathematics representatives on the workgroup have questioned whether a compressed, five-week remote course can provide an adequate pre-calculus foundation; the data in Figure 26 represent such a compressed remote format. Summer Bridge has been in the process of re-evaluating the academic content of the program. As such, Math 3C and 10A are no longer program options. Rather, the emphasis has shifted towards more holistic alternatives such as Accelerate to Calculus. This latter approach has the potential to set students up for success when they take the course assigned to them through placement during the academic year, complete with the learning community support.

Before 2020, Summer Bridge concentrated on the transition to campus life through specialized instruction, peer mentors, and on-campus community building. In Summer 2020, an academic component was added to the program; students enrolled in courses in Education Studies, Analytical Writing, and Mathematics, among others. Several courses operated on a cohort model and had sections reserved for Bridge students. We now see a shift back towards the original conception, albeit with limited academic options. In particular, Summer Bridge should not be seen as a math remediation program.

The new approach to Bridge launched in 2020; because of the pandemic, it was entirely remote, precluding the residential component. Beginning in 2021 students have had the option to participate in residence or remotely, resulting in a significant increase in participation:

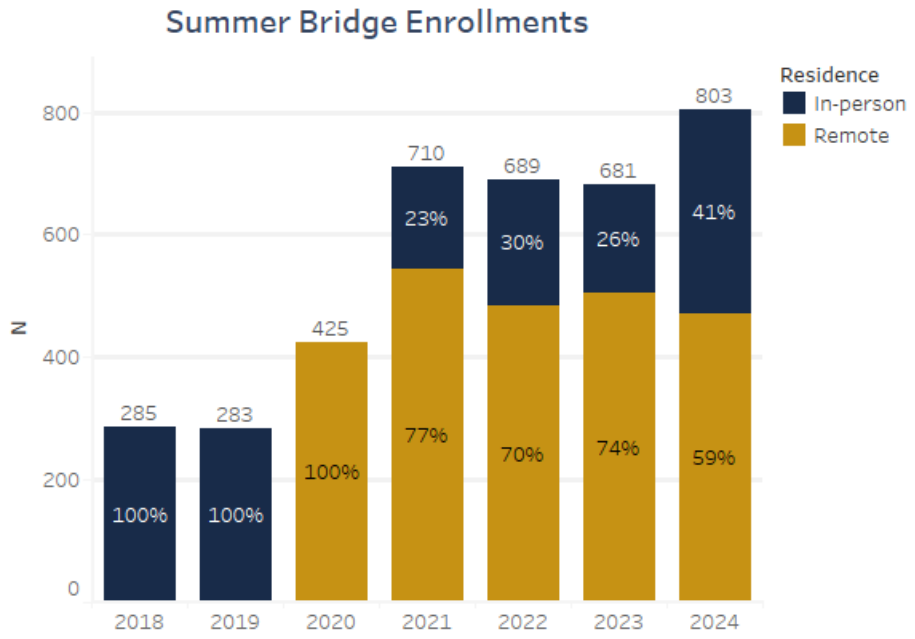

Figure 27

An overarching goal of Summer Bridge – one that bears on all of the goals discussed above – is to create a sense of belonging throughout the year for students who might otherwise feel marginalized. The program administers pre- and post-surveys to measure this objective on a five-point scale. Paired samples t-tests quantified the 2021 results as follows:

Question	Pre-survey	Post-survey	p-value
Self-rated confidence in their ability to be involved in campus life	*M* = 3.12 *SD* = .476	*M* = 3.30 *SD* = .503	p < .001
Sense of comfort with being who they are at UC San Diego	*M* = 3.20 *SD* = .487	*M* = 3.33 *SD* = .555	p < .001
Belief that educators at UC San Diego will value their lived experience	*M* = 3.13 *SD* = .418	*M* = 3.34 *SD* = .474	p < .001

Figure 28

Qualitative analysis involved student focus groups; in these, students commented on how the program made them feel welcomed to campus, less intimidated by large classes, created bonding, addressed under-represented student identities vis-à-vis the university, boosted confidence, and increased motivation.

Figures 29 and 30 show that one- and two-year retention rates for Summer Bridge students are better than the Bridge comparison group (students with similar demographics who did not participate in Bridge); there are more mixed results when comparing Bridge students with all students:

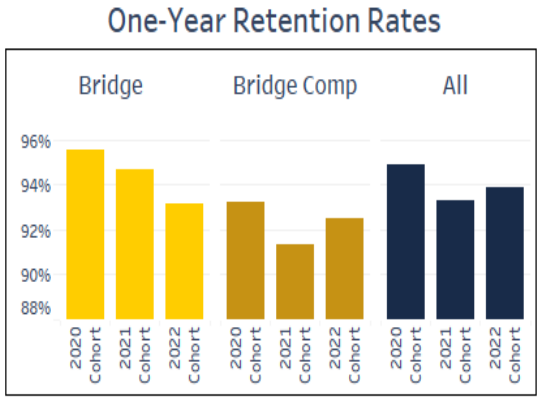

Figure 29

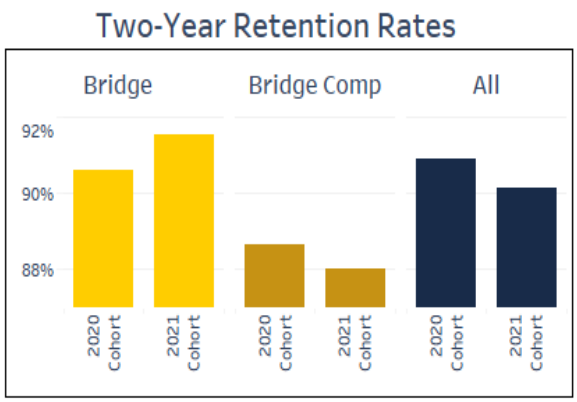

Figure 30

Throughout this discussion of curricula and student support, there are many variables in play: a revised Math 2 curriculum, the introduction of 3B, a redistribution of supplemental instruction, the recent addition of Accelerate to Calculus, and the sunsetting of 3C/10A Summer Bridge options. This will make assessment challenging; however, it also provides an opportunity to look into how curriculum and student support programs can collaborate to address equity gaps.

This section underscores that resources are critical to supporting student success – particularly when students arrive with a range of skills. Some members worry that the magnitude of the problem is beyond what the campus can realistically devote resources to.

Finally, it is notable that the student voice is absent from these discussions. It is important that as we design curricula, refine pedagogy, and provide support, we understand how students experience their journey through mathematics. OASIS and the Teaching + Learning Commons are well positioned to conduct focus groups in this area.

4. K-12

First-year students come to UC San Diego with the math preparation they have attained in their K-12 years. UC admissions requirements include three years of college preparatory math, including elementary and advanced algebra and two- and three-dimensional geometry. Students with this minimum preparation should be able to place into Math 3C or, perhaps 10A/4C. However, we have seen that many students – despite passing these courses – are not prepared and place into 3C (at the lower end of the spectrum) or into Math 2; as discussed above, the Math 2 population is heterogeneous and often includes students with preparation closer to the elementary school levels.

The workgroup invited an expert in K-12 education to discuss some of the sources of these challenges – highlights of that discussion include:

1. **Curriculum Development**: Focus on enhancing data science and financial literacy courses to include substantial mathematical content, with potential university partnerships to ensure rigor.

2. **Calculus Preparation**: Emphasis on adequate preparation for calculus, redesigning school structures, and addressing limited availability of advanced math classes.
3. **COVID-19 Impact**: Significant disruptions due to the pandemic have led to gaps in foundational skills, particularly for students who were already struggling.
4. **Technological Reliance and Learning Gaps**: Concerns about overreliance on technology, which may hinder basic computational skills, and potential shifts in education technology usage. Issues include reliance on calculators and online homework replacing traditional methods.
5. **Teacher Development and Qualifications**: Efforts to improve professional development for math teachers and challenges in finding qualified teachers.
6. **Parental and Teacher Support**: Need for better support for parents and teachers in understanding and teaching new standards like Common Core, and addressing attention span issues due to technology.
7. **Equity and Access**: Issues with equitable access to advanced math courses and leveraging dual enrollment in community colleges as a potential solution. High school courses are often capped or canceled due to low enrollment.
8. **Systemic Challenges**: Discussion on the chaotic state of the education system exacerbated by the pandemic, and examples of inconsistencies in teaching quality and course availability.

The committee discussed how the UC System might collaborate with high schools to provide academic support for teachers and aid in curriculum design. UC San Diego's CREATE sponsors several outreach and tutoring programs and several Mathematics faculty are engaged with local high schools. The UC Office of the President lists several outreach programs, including MESA, which works with under-served high school students to achieve success in STEM careers. A 2023 Policy Analysis for California Education report details the work of six other intersegmental partnerships. While it is beyond the scope of this workgroup's charge to address K-12 challenges, it is also true that the source of equity gaps in preparation are closely tied to variable K-12 experiences. To this end, another National Academies of Sciences, Engineering, and Medicine's report on Equity in K-12 STEM Education is of particular relevance.

5. Recommendations

Emphasizing the complex nature of the data and landscape, we suggest recommendations, based on the following principles:

- We have an obligation to support our students, all of whom bring their unique assets, and deserve to be at UC San Diego.
- Variability in K-12 instruction will inevitably result in a range of math preparation. These contribute to equity gaps in retention and graduation rates.
- The Department of Mathematics has an immense task in supporting thousands of students – in a wide variety of majors. Adding varying degrees of preparation makes this task more difficult and requires resources.
- Acquiring the skills necessary for success in calculus can take time. Depending on a student's level of preparation, there may not be a quick way to move into the calculus sequences.

- Supporting our students will require collaborations between Mathematics, other departments, the Teaching + Learning Commons, and OASIS.
- Practices that support student success do not need to result in less rigor.

Recommendations:

1. Work to standardize pedagogy and curricula in the math sequences, consider partnering with the TTC and Prairie Learn pilot.

2. Consider creating discipline-specific sections in calculus courses to aid in the application of math topics in other STEM areas.

3. Ensure that the Teaching + Learning Commons, OASIS, and Summer Bridge are adequately supported and collaborate closely with Mathematics on student success initiatives.

4. The Math Department should continue to monitor the results of the Math Placement Exam; collect data on repetitions, changes in placement, and downstream student success.

5. The Math Department should continue to monitor student performance in Math 2, 3B, 3C, 4C, and the 10 and 20 series. Look at a variety of metrics to measure how students are acquiring learning outcomes. Cross reference these findings with measures of student success in other areas.

6. Departments that require calculus should evaluate their curricula to see which learning outcomes are actually needed. This might result in different requirements (e.g., the 10 series instead of the 20 series, fewer calculus courses, …).

7. Departments that, after evaluation, need calculus learning outcomes are encouraged to use curricular analytics tools to provide students with multiple recommendations on pathways they can follow to acquire the required calculus background.

8. Ensure that the advising community has bandwidth and access to resources to adequately advise students who place into Math 2 (and, possibly, Math 3B/C). Consider an auto-trigger for proactive advising for these students.

9. Conduct student focus groups to better understand how students are experiencing their math education.

10. Continue to monitor and participate in the K-12 partnerships discussed in Section 4.

11. Ensure that relevant parties discuss and evaluate the recommendations of the National Academies report on undergraduate STEM education.

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John Moore, Undergraduate Education, Co-chair
Hailey Caraballo, Undergraduate Education
Aaron Coleman, Biological Sciences
David Quarfoot, Mathematics
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Alyssa Taylor, Bioengineering
Paul Yu, Revelle College

Appendix – Workgroup Charge

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October 23, 2023

Subject: Charge for Senate-Administration Workgroup on Math Preparation

There is crucial need for a Senate-Administration workgroup on math preparation at UC San Diego. The workgroup will address the barriers to academic success, retention, and time to degree that disproportionately affect historically marginalized students, including first-generation students and students from underrepresented and minority populations. This is an equity issue that has gone largely unaddressed.

As a university, we aspire to the following outcomes:

1. Eliminate equity gaps in math education at UC San Diego.
2. Increase student sense of belonging and academic confidence in mathematical contexts.
3. Reduce DFW rates in math-intensive courses.
4. Optimize math pathways, with an eye toward degree completion and time to degree.

The establishment of a Math Preparation Workgroup is necessary to make fundamental progress toward reaching these outcomes. Bringing together academic and administrative leaders with expertise in this area will benefit our most vulnerable students and the entire university community.

Background

About 80% of UC San Diego students currently require some portion of a calculus sequence for graduation requirements. Yet, in recent years, due to a variety of external and systemic factors, including equity gaps, instead of being a synergistic part of students' educational experience, learning calculus has increasingly become a barrier to students' success and time to degree. In Fall 2022, 37% percent of students who required calculus were placed into additional preparatory classes. As the table below

shows, first-generation and underrepresented minority students were vastly overrepresented in this group compared to students who placed directly into calculus.

Demographics of preparatory placements (2022)

Placed into preparatory courses (N=2700)		**Placed into Calculus (N=3141)**	
1st-Gen 59% (1589)	Non 1st- Gen 41% (1111)	1st-Gen 25% (779)	Non-1st Gen 75% (2362)
URM 54% (1458)	Non URM 46% (1242)	URM 14% (425)	Non URM 86% (2716)
Both URM and 1st- Gen 40% (1088)	Neither URM nor 1st-Gen 27% (741)	Both URM and 1st-Gen 8% (237)	Neither URM nor 1st-Gen 69% (2174)

Even beyond these preparatory classes, the calculus sequence DFW rates are high (between 9% and 15%, depending on the class), further slowing progress towards degree and negatively affecting student belongingness and wellbeing. Marginalized groups also receive higher DWF rates in the calculus sequence, compared to (e.g., 20% DFW for URM students vs 11% for non-URM students). Our current structures, while designed to support students, are not successful at closing equity gaps that existed before students entered our program. This has significant downstream effects in terms of equity gaps for both retention and four-year graduation rates. We emphasize that all of these students have been admitted through a selective and rigorous admissions process.
Hence, while not all students come to UC San Diego with the same background in math education, they are all qualified students. As a university, we have a shared obligation to support the success of all of our students.

Charge

While this challenge is not unique to UC San Diego, we have an obligation to serve and be prepared to educate our students - all of whom have been admitted through a selective process. We should pay particular attention to pedagogies that are showing great promise with respect to closing these equity gaps, promising solutions seen at other institutions, and the development and implementation of proposed solutions that would better serve our students and their aspirations.

We propose that the workgroup address the following questions:

1. How do disparities in math placement contribute to equity gaps?

2. How do existing approaches to testing, placement, and curriculum structure contribute to these equity gaps?
3. What impacts do the current set of preparatory math courses and support programs have in closing these gaps?
4. Are there asset-based alternatives to our current approach to placement or preparatory courses that would more effectively address equity gaps and advance student success goals?
5. What effective strategies have been implemented at UC San Diego and at comparable universities?
6. What recommendations does the workgroup have for promising pathways that will close equity gaps in the math sequence, and subsequently close equity gaps in retention and time to degree?

We would appreciate a written report by end of Spring quarter 2024.

With best regards,

Elizabeth H. Simmons
Executive Vice Chancellor