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New Eligibility Rules for the University of California?

The Effects of New Science Requirements

SUMMARY

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Technical appendices to this report are available on the PPIC website.

The University of California (UC) requires high school students to complete a series of college preparatory courses across a broad range of subjects, referred to as the A–G subjects, to be eligible for admission. In February 2018, UC's Academic Senate approved a proposal to increase the high school science admissions eligibility requirement—known as area D—from two years to three. The proposal would bring its admissions eligibility in line with the new K–12 Next Generation Science Standards (NGSS) and allow additional science courses to meet the expanded requirement, reflecting the broader range of science disciplines included in NGSS.

If adopted, UC's new policy could improve student science learning and readiness for college. But a critical concern is how the proposed science requirements may affect student eligibility for UC, particularly among underrepresented and disadvantaged student groups. California already ranks near the bottom in high school to four-year college enrollment, and more than three-fourths of Californians are concerned about access to four-year colleges.

In this report, we examine the proposal's potential impact. Based on our analysis of a sample of high school graduates who completed the A–G requirements during the 2017–18 school year, we find that:

- The overwhelming majority of A–G graduates have completed at least three years of area D. But 19 percent completed only two years and may be affected by the new proposal.
- There are substantial racial/ethnic disparities: Asian American and white students are more likely to meet the new requirements than Latino or African American students.
- Half of the affected students were not enrolled in an area D course in grade 9. Instead, most took a science elective that does not count toward area D completion. Earth science, which did not meet area D requirements until the 2019–20 school year, accounts for half of all science electives.
- Although students who may be affected have a high probability of taking another year of area D, many do not do so partly because of institutional factors such as course placement, grading policy, course validation rules, course counseling, and scheduling.
- Expanding science offerings may pose hiring difficulties for schools, particularly those with more disadvantaged students. Many have at least one science course with an inappropriately certified teacher.

In light of our findings, we make the following recommendations:

At the University of California:

- Move all science electives into area D. This could reduce the number of potentially affected students by nearly half, and especially benefit Latino and African American students.

- Adopt a phase-in period to allow high schools time to adjust course schedules and offerings. The equity implications—including how many and which high schools have submitted their science electives to area D—should be closely monitored and sufficiently addressed before finalizing these changes.
- Engage in vigorous statewide outreach, so students, parents, counselors, and teachers are well informed about the change (before ninth grade). Effective communication about the benefits of a third year of science, particularly for students not interested in STEM majors, will be critical.

At high schools:

- Submit all eligible science electives for inclusion in area D as UC expands its list. This would make it easier for students to meet the new requirements.
- Review and revise course placement and counseling policies to ensure that academically prepared students enroll in area D courses.

For state policymakers:

- Allow science teachers to teach computer science courses—which, effective 2019, may count toward area D.
- Increase the efforts to prepare, recruit, and retain science teachers, particularly in high-need schools.

The full effects of the proposed change, if approved, depend crucially on implementation. If implemented correctly, the new requirement could improve the way science courses are taken in California high schools and help level the playing field for underrepresented students in gaining admission to highly selective universities. However, careful and continuous attention to the equity implications are necessary to ensure that the policy does not have a disproportionate impact on the state's most disadvantaged students.

Introduction

Most California high school graduates who enroll in a four-year college go to one of the state's public universities (California Department of Education 2019; Kurlaender et al. 2018). To be eligible for the University of California (UC) and the California State University (CSU), they must complete a set of college preparatory courses commonly known as the A–G courses. The current science requirements—area D—include two years of laboratory science in biology, chemistry, or physics (see text box).

A–G course requirements

To meet minimum admission requirements, students must complete 15 year-long college preparatory courses with a letter grade of C or better—at least 11 of them prior to the last year of high school.

Area	Minimum requirements
A: History	2
B: English	4
C: Math	3 (4 recommended)
D: Laboratory science	2 (3 recommended)
E: Language other than English	2 (3 recommended)
F: Visual and performing arts	1
G: Electives	1

Over time, UC has made changes to the A–G requirements infrequently:

Year	Changes
1977	Increased English from 3 to 4
1987	Increased math from 2 to 3
1990	Increased history from 1 to 2
1990	Increased science from 1 to 2
1999	Included visual and performing arts
1999	Decreased electives from 2 to 1
2018 (proposed)	Increased science from 2 to 3*

SOURCE: University of California Office of the President (UCOP), various years.

NOTES: Based on the years when the proposed changes are approved. * not yet approved by the Board of Regents. This list does not include the changes CSU has made over the years.

In 2013, California's State Board of Education adopted the Next Generation Science Standards (NGSS) for K–12 schools. These standards include both a broader set of courses *and* different ones than UC and CSU currently use to determine eligibility. In 2018, with the goal of improving high school science learning and aligning entrance requirements with NGSS, UC's academic senate proposed to increase the area D requirements from two years to three (Table 1). The proposal would also change the name of the area D requirements from "Laboratory Science" to "Science" to reflect NGSS's broader range of science disciplines (University of California Academic Senate 2018).

NGSS reframes the high school science curriculum into four core categories: physical sciences; life sciences; earth and space sciences (ESS); and engineering, technology, and applications of sciences. It allows high schools to choose from three models, which determine how students may fulfill the new requirements (California Department of Education 2016):

- A three-course model, which combines high school standards into three courses: Living Earth, Chemistry in the Earth System, and Physics of the Universe, with each course integrating ESS.
- A four-course model, which includes life science/biology, chemistry, physics, and ESS as a standalone course.[1]
- An integrated model (called "Every Science, Every Year"), which is typically seen internationally and presents all major sub-disciplines in three successive courses: integrated science I, integrated science II, and integrated science III.

To date there is no research on the effectiveness of each course model. Early evidence suggests that the three-course model is the most popular option among high schools (Gao et al. 2018). Students in an integrated science model can fulfill the new requirements by completing the integrated sequence. Those in a three- or four-course model can take a third course from the NGSS disciplines, including earth and space sciences, interdisciplinary sciences, computer science, engineering, and applied sciences (UCOP 2018).

TABLE 1

UC's current and proposed new area D requirements

Before 2018	Effective 2019–20	Effective 2019–20	*Pending*
Two (2) years of laboratory science in two of three subjects: —Biology —Chemistry —Physics	One (1) year of area D interdisciplinary or earth and space science can meet one year of the requirement	Computer science, engineering, or applied sciences area D courses can be used as an additional laboratory science (i.e., third year and beyond)	Three (3) years of laboratory science in at least two of three subjects: —Biology —Chemistry —Physics Change the name of area D from "Laboratory Science" to "Science"

SOURCES: UCOP 2018–19.

NOTES: UC and CSU differ in specific requirements. For instance, students may use one year of area G science to fulfill the area D requirements for CSU. If a student repeats a course, CSU takes the highest grade into the GPA calculation; whereas UC takes the first instance of a grade of C or better earned in a course. CSU also validates chemistry, which gives students taking more advanced coursework and receiving a grade of C or better credit(s) for a deficient grade or omitted coursework within the same discipline. For instance, a student who fails both semesters of chemistry 1 but then passes the first semester of chemistry 2 will get credit for 1.5 years of chemistry.

[1] The three-course model and the four-course model do not have a set sequence and local districts can decide the order in which these courses may be offered.

The proposal to add a third year of science has four primary potential benefits.

1. Successful implementation of NGSS requires at least three years of science learning in high schools (National Research Council 2012). By aligning admissions requirements with the K–12 standards, the proposal supports NGSS implementation and could lead to a better transition from high school to college.
2. Encouraging more students to take a third year of college preparatory science—along with broadening the list of courses that satisfy the science requirement—is important for improving high school outcomes, postsecondary enrollment, and (to a lesser extent) college performance and labor market earnings.[2]
3. Depending on implementation, it could lead to a more diverse set of students pursuing science, technology, engineering, and mathematics (STEM) majors. Many would regard this outcome as a victory due to strong career options for STEM majors and high rates of underrepresentation among some demographic groups.
4. UC applicants with only two years of science are at a disadvantage, especially if they aspire to the more selective campuses. Most institutions with similar selectivity (i.e., Barron's ranking) and freshmen enrollment require three or more years.[3] The admission rate for underrepresented applicants with only two years of area D ranges from 33 to 45 percent. That is significantly lower than for those with three years—50 to 62 percent (UCOP 2018).

The proposal also has some negative consequences.

1. An earlier study suggests that even though the vast majority of UC applicants have completed three years of science, applicants from underrepresented groups are less likely to do so (UCOP 2018). The proposal may leave these students further behind, especially if their high schools do not offer sufficient access to three years of area D.
2. An even larger share of underrepresented students completed only one area D course. Getting those students to successfully complete three years of science is a much heavier lift than two years.
3. The opportunity cost of taking another year of science may be significant, particularly for students pursuing non-STEM majors. For students who may be affected by the proposal, an additional year may crowd out other coursework that may be more germane to their intended majors.[4]
4. Difficulties in hiring and retaining qualified science teachers may impose another challenge, especially for high-need schools (Darling-Hammond et al. 2018).[5]

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[2] There is considerable research on the importance of taking rigorous courses in high school. For example, see Bryk, Lee, and Smith (1990); Gamoran (1987); Long et al. (2012); Aughinbaugh (2012); Adelman (2006); Long, Iatarola, and Conger (2012); Clotfelter et al. (2019); Rose and Betts (2004); Goodman (2019); Gaertner (2013); Levine and Zimmerman (1995).

[3] We identify colleges with the same Barron's selectivity ranking as UC campuses, ranging from very competitive to most competitive. This gives us 1,018 colleges. We then select colleges enrolling 30,000 or more students, which is comparable to the freshmen enrollment at most UC campuses. Our final sample includes 34 colleges. We collected the freshmen course requirements from each college's admission website, and 26 (81%) of them require 3 or 4 years of sciences.

[4] As we will see later, this does not appear to be a major concern in our sample. Graduates with only two years of area D tend to earn fewer credits in other subject areas as well (Technical Appendix C, Table 2). It's possible that these graduates may have taken more non-A–G courses, which we cannot observe in our sample.

[5] A related concern is that the proposal does not incentivize schools to improve or maintain the quality of area D courses. Existing evidence suggests that the advanced courses that high-minority or high-poverty schools offer do not always reflect the actual content and rigor of the intended curriculum (Hallett and Venegas 2011; Dougherty et al. 2006). To be clear, Dougherty et al. (2006) only studied the quality of AP courses in Texas (because of the availability of the longitudinal student data). It is possible that UC's A–G course approval process largely mitigates this concern.

It is important to understand that right now there are very little data available for determining the extent to which UC's proposal would affect schools, high school students, and college applicants. However, now is the critical juncture for making sure the decision is based on the best available data and evidence.

In this report, we leverage data from a variety of sources to examine the potential impacts of the new proposal. First, we use administrative records from the Transcript Evaluation Service (TES) and the A–G Course Management Portal (CMP) to identify the number and types of schools and students that may be affected by the proposal.[6] Next, we look at institutional factors that may encourage affected students to take another year of science through interviews with science teachers and school administrators. We then use administrative records from Cal-PASS Plus (CPP) to explore the benefits of a third year of science on postsecondary enrollment. Finally, we conclude by offering policy recommendations.

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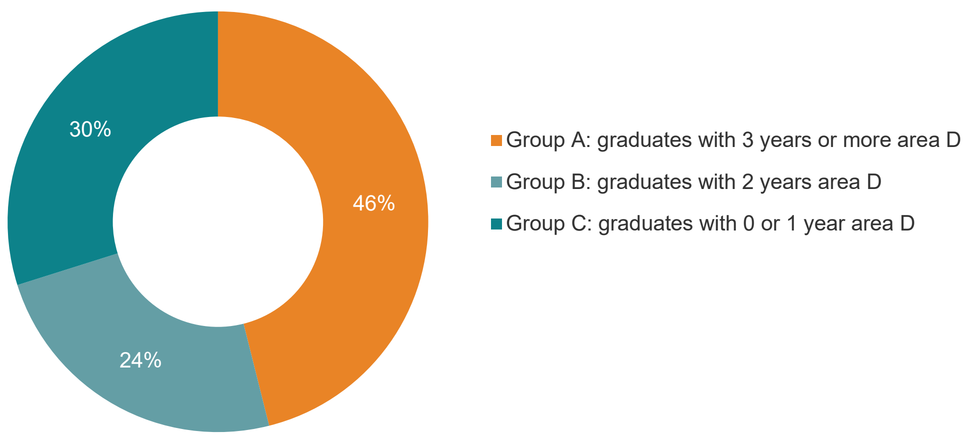
[6] We considered other sources, including course records data from the California Department of Education (CDE). CDE's course data tend to undercount the number of A–G courses—in the 2017–18 school year, the undercount was 27 percent. This could be due to a number of reasons. First, some of the local course codes may not have a one-to-one match to the CALPADS Course Group State codes. Second, CALPADS submission guidelines list state course codes that are *most likely* to meet UC/CSU requirements, and it is up to the LEA to determine whether a specific course code has been approved by UC/CSU for the LEA. Third, CALPADS data are not audited.

How Would a New Science Requirement Affect Students' College Eligibility?

How students—disadvantaged students in particular, including Latino and African American students—may fare under the new proposal is at the heart of the policy discussion. To provide context on student course taking, we use administrative records from the Transcript Evaluation Service (TES) and Cal-PASS Plus (CPP).[7] We group students into three categories based on their likelihood of meeting the new science requirement: Group A, Group B, and Group C (Figure 1).

FIGURE 1

Graduates with two years of area D are more likely to be affected by the proposal



SOURCE: TES, 2017–18.

NOTE: All high schools in the TES sample offered at least three years of area D.

Group A (46%). These students have already completed at least three years of area D. They are not affected by the new requirements.[8] White, Asian American, and female students are more likely to be in Group A (Figure 2).

Group B (24%). These students have completed only two years of area D and may be affected by the proposal. Based on their course-taking patterns, those likely to take a third year of science would be positively affected because of the benefits of taking rigorous science courses (Long, Conger, and Iatarola 2012; Sadler and Sonnert 2010).[9] Those less likely would be negatively affected, because they would be ineligible for UC. Male, Latino, and African American students are more likely to be in Group B than female, white and Asian American students (Figure 2).

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[7] Our TES sample includes 56,320 high school graduates during the 2017–18 school year. Although the coverage is low (representing 14% of high school graduates), TES includes complete high school transcripts, which allows us to examine students' course-taking records throughout high school. Our CPP sample includes 1.6 million high school graduates between school years 2007–08 and 2017–18 (representing 35% of the state's high school graduates). The CPP data include postsecondary enrollment, which allows us to examine the benefits of an additional year of science. Latino students and low-performing students (i.e., non-A–G completers) are overrepresented in the TES sample (Technical Appendix A, Table 1); and first-generation college students are overrepresented in the CPP sample (Technical Appendix B, Table 1).

[8] We define completion as completing an area D course with a C or better. In the TES sample, 11 percent of graduates repeated biology and 6 percent repeated chemistry. The repeat rate is much lower (<4%) among A–G completers.

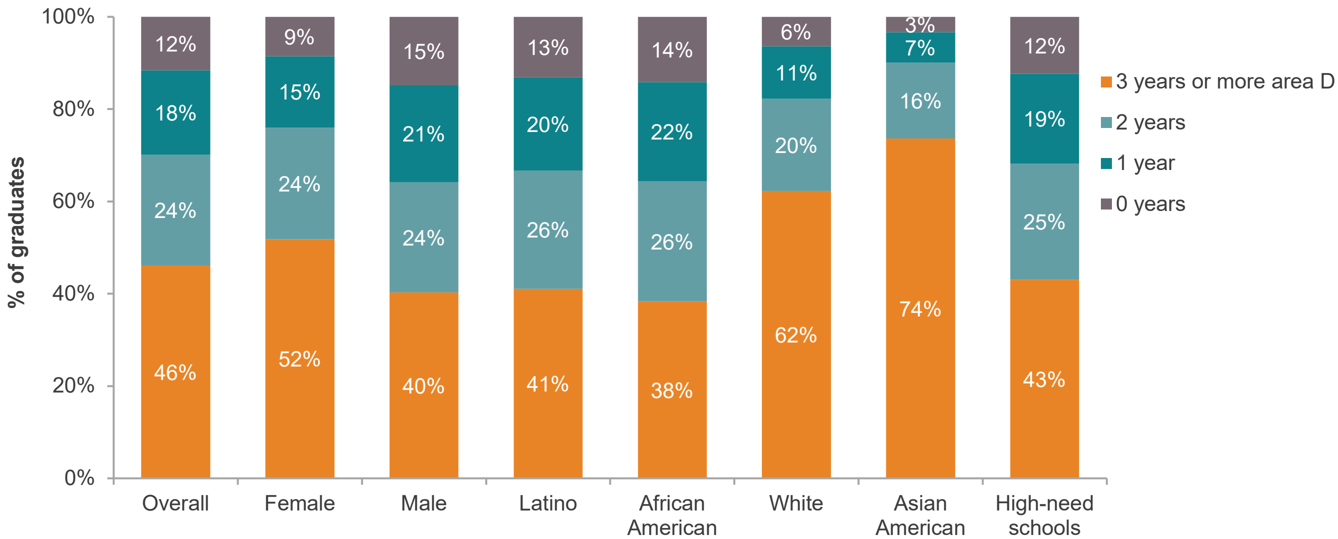
[9] One concern is that the additional science may crowd out other coursework. Our data suggest that this may not be very significant, as graduates with two years of science tend to take fewer units in all subject areas. That being said, it is possible that these students may be taking non-college preparatory courses.

Group C (30%). These students have at most completed one year of area D, perhaps because they were placed in the sequence too late (e.g., in 12th grade) and/or cannot complete the *current* sequence by the time of graduation. They are not likely to be affected by the proposal. It is important to note that the proposed increase in area D would take these students even further away from potentially becoming UC eligible. Notably, 33 percent of Latino and 36 percent of African American graduates do not meet the current area D requirements, compared to only 10 percent of Asian American and 17 percent of white graduates (Figure 2).

Because nearly 90 percent of TES schools are high-need schools—schools where more than 55 percent of students are low income, English Learners and foster youth—the results are very similar when we restrict the sample to high-need schools only.[10]

FIGURE 2

More than a third of Latino and African American graduates do not meet the current area D requirements



SOURCE: TES, 2017–18.

NOTES: All high schools in the TES sample offered at least three years of area D. Subgroup analysis for high-need schools yielded very similar patterns and are included in Technical Appendix C, Table 1.

Next, we looked at how students who had completed A–G requirements handled area D, for two reasons. First, students who do not complete are not eligible for UC or CSU, no matter how many area D courses they take. So they are not likely to be affected by the proposal.[11] Second, equity concerns may loom large among this group, as statewide data show Latino and African American students are disproportionately less likely to complete the A–G requirements (CDE DataQuest 2018).[12]

We find that nearly one in five (19%) A–G graduates completed only two years of area D courses and so may be affected (Figure 3). About 10 percent of white or Asian American students are in this group, and the share more than doubles among Latino and African American students (23%).

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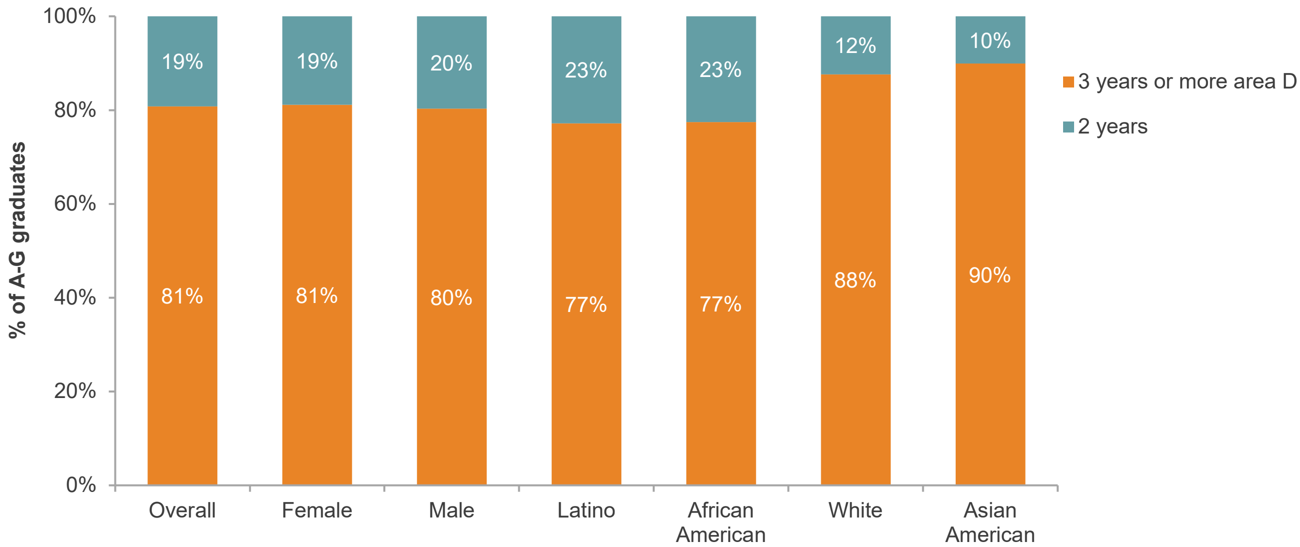
[10] Only 10 percent of high schools in our TES sample are not high-need schools, which makes the sample size too small to draw any meaningful conclusions from.

[11] In our sample, a third (30%) of graduates with two years of area D completed A–G; most of those who did not failed the math (47%) or English (38%) requirements.

[12] The conclusions based on all high school graduates are very similar and the corresponding results are included in Technical Appendix C.

FIGURE 3

Latino and African American A–G graduates are more likely to be affected by the proposal



SOURCE: TES, 2017–18.

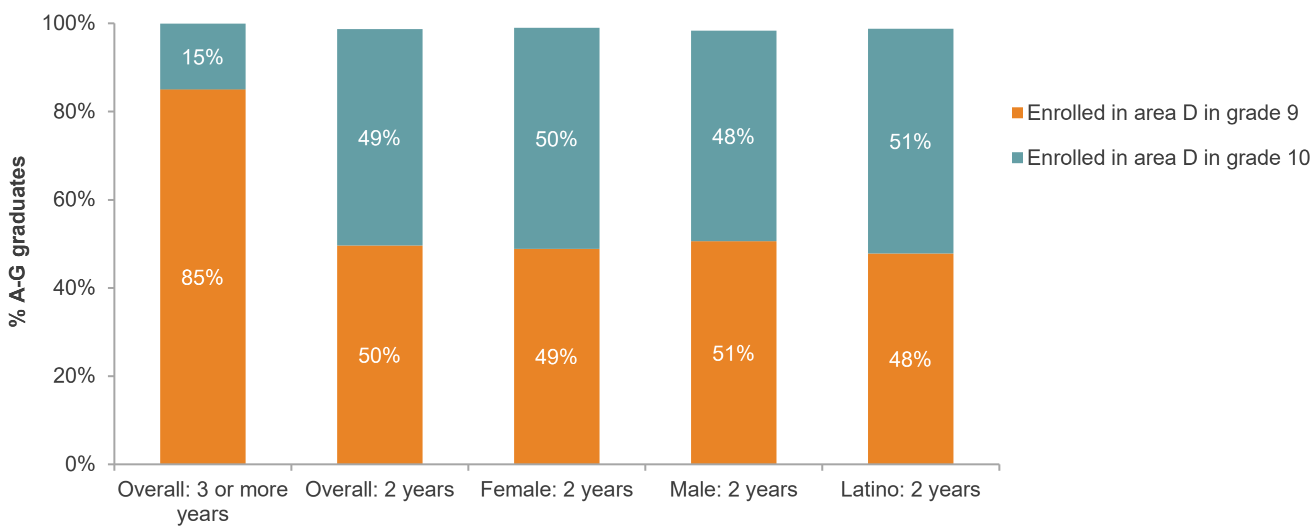
NOTE: All high schools in the TES sample offered at least three years of area D.

Affected Students Tend to Start the Required Science Sequence Late

The vast majority (85%) of A–G graduates who would not be affected if the proposal is implemented (Group A) were enrolled in the science sequence in ninth grade, compared to only 50 percent of those who would be (Group B) (Figure 4). Across subgroups, Latino and African American graduates were more likely to enroll in the sequence late—26 percent of Latino students started the sequence in 10th grade.

FIGURE 4

Most affected graduates are enrolled in the area D science sequence in 10th grade for the first time



SOURCE: TES, 2017-18.

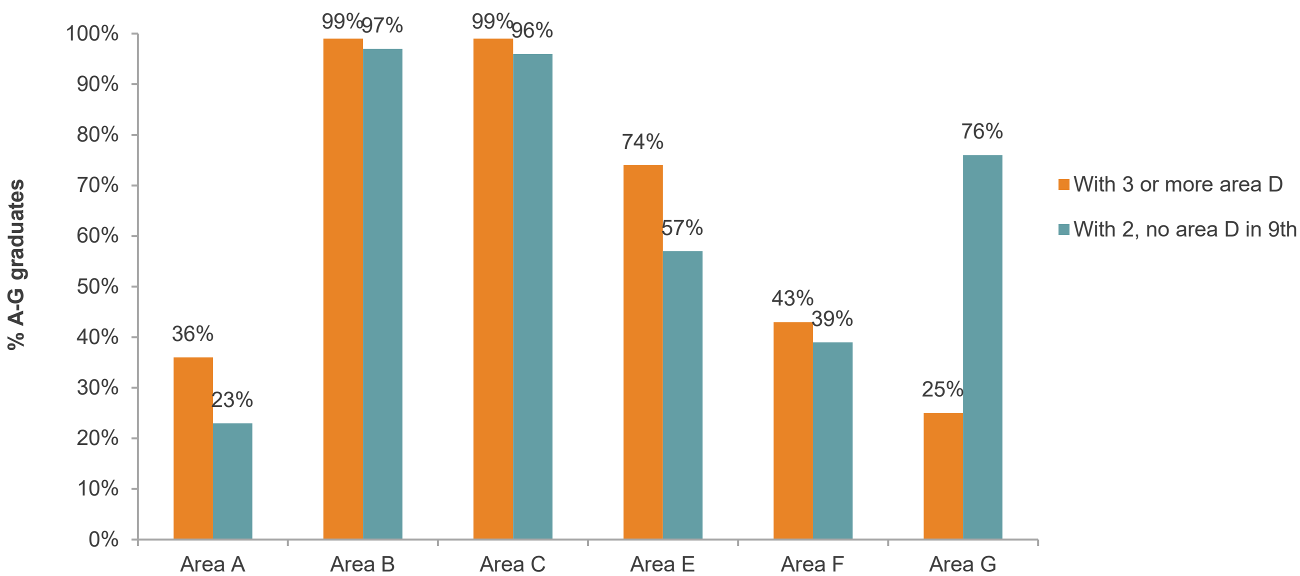
NOTES: Overall: 3 or more years refer to all A-G graduates with 3 or more area D; similarly, Latino, 2 years refer to Latino A-G graduates with 2 years of area D.The numbers in the last bar may not add up to 100 because a relatively small number of graduates started their sequence in 11th grade. Because of small sample issues, we did not report the racial/ethnic breakouts of affected students. Results for the full sample (including students who did not complete A–G) are very similar.

Why do some students start the area D sequence late? Some possible explanations include student selection (e.g., strongly motivated, academically well-prepared students are more likely to be placed into and pass an area D course), course placement, counseling practices, and science course sequencing. Our transcript analysis suggests that student preparation explains only a small share of the difference (Technical Appendix C, Figure 1).

On the other hand, we find strong evidence that the A–G course criteria played an important role, as affected students are much more likely than non-affected students to be enrolled in a science elective (area G) in ninth grade. Science electives include interdisciplinary courses and courses beyond biology, chemistry, and physics. They could provide academically challenging study at the same level of rigor as area D courses; however, most of them were not allowed to count toward area D completion until very recently (UCOP 2019). To illustrate, Figure 5 shows the course-taking patterns among students who were placed in an area D course in ninth grade and those who were not. The vast majority of affected graduates (76 percent) took an area G elective course in ninth grade.[13] Over 90 percent of these area G courses are science electives (Figure 6), with earth science being the most popular one, accounting for 45 percent of all electives.[14]

FIGURE 5

Affected students are placed in a science elective instead of area D science in ninth grade



SOURCE: TES, 2017–18.

NOTES: All high schools in the TES sample offered at least three years of area D. Results using the full sample (including students who did not complete A–G) are very similar. The affected sample—the number with A–G graduates with two years of area D but who did not start the area D until 10th grade or later—is too small for any meaningful breakdown by gender or race/ethnicity.

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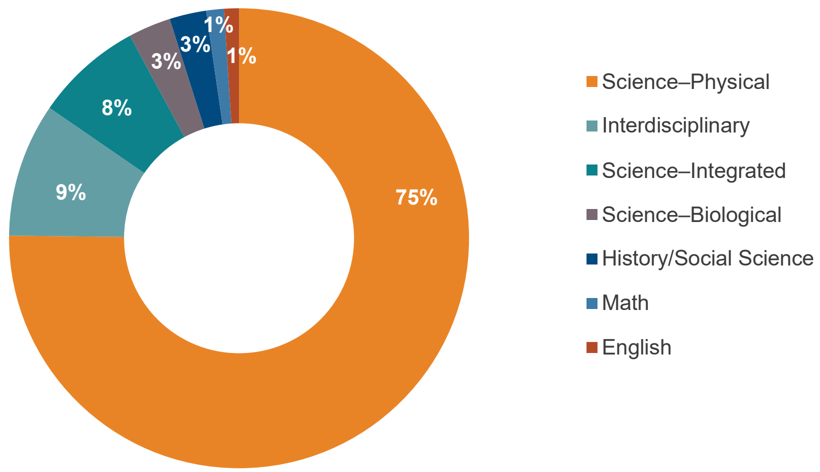
[13] Students who do not take area D courses may also take more courses outside A–G, which we are unable to observe due to data limits.

[14] Other physical science courses account for 29 percent of all electives. The finding is not specific to a few high schools, in which students resort to electives because not many area D courses were offered.

FIGURE 6

Science makes up the majority of area G electives in ninth grade



SOURCE: TES, 2017–18.

NOTE: All high schools in the TES sample offered at least three years of area D. Results using the full sample (including students who did not complete A–G) are very similar.

Including Science Electives in Area D Could Solve Eligibility Problems

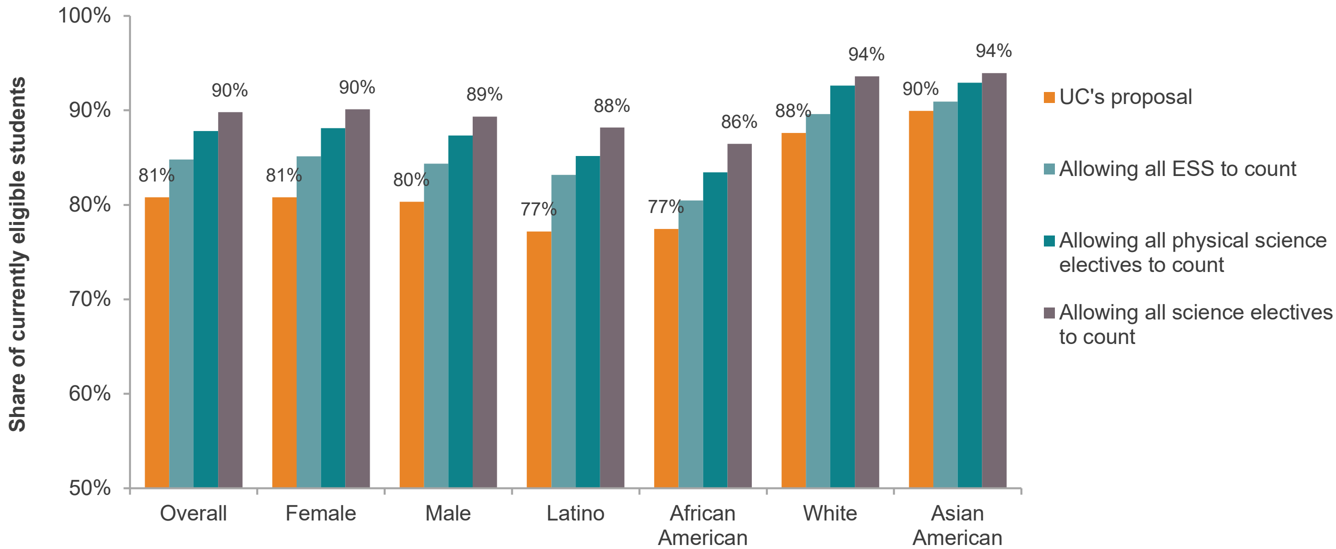
Given the popularity of science electives—especially among affected students—an immediate low-cost policy solution is for high schools to submit their science electives to area D. Science electives can be as academically challenging as area D courses (UCOP 2019), and categorizing them as area D would make it easier for students to meet the new requirements. In fact, effective in the 2019–20 school year, earth science was allowed to count toward area D completion (UCOP 2019).

Moving science electives into area D would increase the number of eligible students (Figure 7). Under the current proposal, 81 percent of students who complete A–G meet the new requirements. The share would increase to 85 percent if all earth science courses are approved as area D. If we include *all* science electives, the share of eligible students would increase to 90 percent. That would reduce the number of affected students by nearly half (to 10% from 19%).

That policy change benefits Latino and African American students, who would see their eligibility rates increase by 11 and 9 percentage points respectively. Consequently, the Latino-white gap would shrink by nearly half (from 11 percentage points to 6 percentage points) and the African American–white gap by almost a third (from 11 to 8 percentage points).

FIGURE 7

More students would be eligible if science electives count toward area D



SOURCE: TES, 2017–18.

NOTES: We consider several scenarios in which certain science electives are allowed to count toward area D completion. In the first scenario, we assume that all earth science courses, which account for 42 percent of all electives, are approved as area D; in the second scenario, we expand the pool to include all other physical science courses; in the third scenario, we assume that all science electives, including earth science, engineering, and computer science are approved as area D. The affected sample is too small for any meaningful breakdown by gender x race/ethnicity.

Affected Students Have a High Probability of Taking Another Year of Area D Science

A critical question is whether affected students might take an additional science course if UC increases its science requirements. Changes in student behavior are hard to predict, but we can provide a partial answer to this question by examining how likely affected students are to have taken an additional area D course, based on their demographic characteristics, grade level, GPA in the previous grade, and science pathways (e.g., starting science in ninth grade). Comparing this likelihood between affected and non-affected students enables us to examine how similar these students are when it comes to their propensity to enroll in an additional year of science. Both groups had very high likelihoods and the differences between them were surprisingly small: ranging from 0.01 to 0.06 (Figure 8, panel A).[15] This suggests that affected students have very similar characteristics, such as previous GPAs, with non-affected students. However, despite having a reasonably high probability of taking an area D class in 11th grade (0.9), 23 percent of affected students were not enrolled in one.

Again, these students are more likely to take science electives, although the difference is not as striking as the one in Figure 5. Half (52%) were placed in an elective, compared to 42 percent of those who took area D courses. Most of the difference stems from history/social science electives and science electives (Technical Appendix C, Table 3).

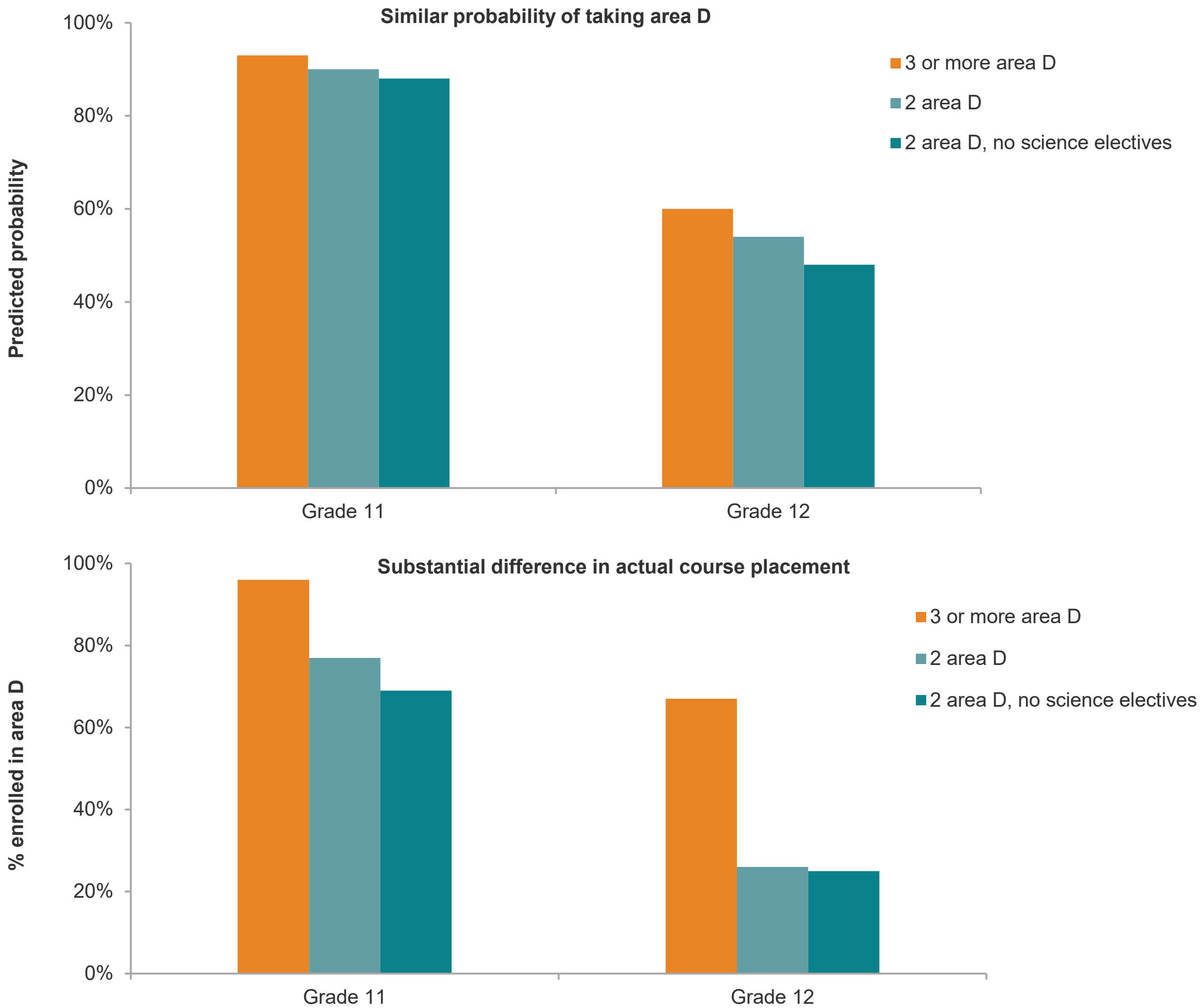
This dynamic is important to note and suggests that institutional policies and practices—not simply academic preparedness—make it difficult for this group of students to get into the area D classes they need. In the next

[15] Predicted probabilities are calculated using a probit model that includes demographics (e.g., race/ethnicity, gender), previous GPA in English, grade when students first took an area D course, grade levels, and school fixed effects. We use GPA in English because the minimum requirement is four years, which means that all students have to take an English course in every grade and hence selection may be less of a concern. In other subjects, such as math, not every student takes a math course in every grade and students in the same grade may be taking different math courses.

section, we will relay our findings from the interviews we did with educators and administrators, to shed light on why these disparities may be happening.

FIGURE 8

Small difference in student probability of taking an area D course but substantial difference in actual course enrollment



SOURCE: TES, 2017–18.

NOTES: (1) Virtually all graduates with at least three years of area D have taken an area D course in 10th and 11th grades; however, the predicted probability is not 1 because our model does not capture other factors that may affect student course-taking, such as course scheduling, parental involvement, and college aspiration. 2) Predicted probabilities are calculated using a probit model that includes demographics (e.g., race/ethnicity, gender), previous GPA in English, grade when students first took an area D course, grade levels, and school fixed effects. 3) Results using the full sample (including non-A–G completers) yield qualitatively similar results. The affected sample is too small for any further breakdown by race/ethnicity and/or gender for certain groups.

Institutional Factors Could Improve Area D Enrollments

Our quantitative analysis shows that most of the potentially affected students have a reasonably high probability of taking another year of science, and yet miss out on the opportunities. Because institutional factors help to explain student course enrollment patterns, we supplemented our data analysis with 41 in-depth interviews with school administrators and science teachers to develop a deeper understanding of barriers students face.[16] Our interviews identified the following issues:

Course scheduling. There is competition between science and other subjects such as math, English language arts (ELA), language other than English (LOTE), and electives. By many measures, science has taken a back seat to math and ELA (Gao et al. 2018) and adding another year of science would affect course scheduling in other subject areas. In high-need schools, course scheduling is particularly hard for struggling students who failed the prerequisite math course. For instance, when students fail chemistry in junior year, it will be very hard to take another year of science because of competing schedules in senior year (e.g., fourth-year math). Scheduling may also prove hard for students in programs that run parallel to their regular academic programs, such as the International Baccalaureate (IB), Advancement Via Individual Determination (AVID), Career Technical Education (CTE), English Language Development (ELD), and athletic programs.

Teacher staffing. California is facing a persistent teacher shortage and the trend has become worse in recent years (Darling-Hammond et al. 2018). Finding credentialed science teachers—particularly physics teachers and science teachers with CTE credentials—will be critical in schools' expansion of area D courses. It took one affluent high school three years to find a qualified physics teacher. In high-need schools, the shortage is exacerbated by the high turnover among science teachers. Recent innovations in high schools, including dual enrollment courses at local community college(s) and online vendors such as UC Scout may be a viable option to expand course offerings under staffing constraints—the expansion must be paralleled with effective counseling and support systems.

Comprehensive support system. Students with only two years of area D still see UC as a viable option, but they will need more targeted support. In many high schools, algebra II (or equivalent) is required for chemistry yet too many students are failing it, which limits their opportunities to take the next science course(s). NGSS aims to change that but it may take time. The recent expansion of area D courses is encouraging; however, some students may not have the time to take an additional science course when they have to repeat or make up for their math courses. A comprehensive counseling and support program will be critical to help affected students navigate through the policy change.

Stakeholder buy-in. Respondents agreed that there was a lack of understanding and urgency among stakeholders. Some schools foresee a significant pushback from parents and counselors who do not see the benefit of another year of science—even though a successful implementation of the NGSS and the new science assessment require at least three years of science learning in high schools (National Research Council 2012). Information about the benefits of a third year of science—particularly for students not interested in pursuing a STEM major in college—would be key to gaining stakeholder buy-in and increasing administrative support.

Increasing high school graduation requirements. California is one of the few states that require only two years of science for high school graduation. As a result, fewer students in California than in other states complete three years of science in high school (Gao, Lopes, and Lee 2017; Gao 2019). Local districts can supplement additional requirements, yet most do not (Gao et al. 2018). Student advising sometimes focuses on

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[16] We recruited 41 school administrators, district staff, school counselors, and science teachers who agreed to participate in our 30-minute interviews. Because of the small sample size, we cannot further break down the analysis by school and/or teacher characteristics. The interview was recorded, transcribed, and coded in DeDoose. A copy of our interview questions is included in Technical Appendix D.

high school graduation requirements rather than UC eligibility criteria. Some respondents see the proposal as an opportunity to align their local graduation requirements with the A–G, as NGSS and CAST effectively require at least three years of science (National Research Council 2012).

Equitable course placement, grading policy, and validation rules. Some respondents expressed an urgency to revisit their science placement protocols, teacher grading practices, and course validation rules, as students may be held back due to inequities in these policies and practices. The current policy and practice tend to rely on subjective criteria, which may be biased against low-income and minority students, who in turn are more likely to be affected by UC's proposal.

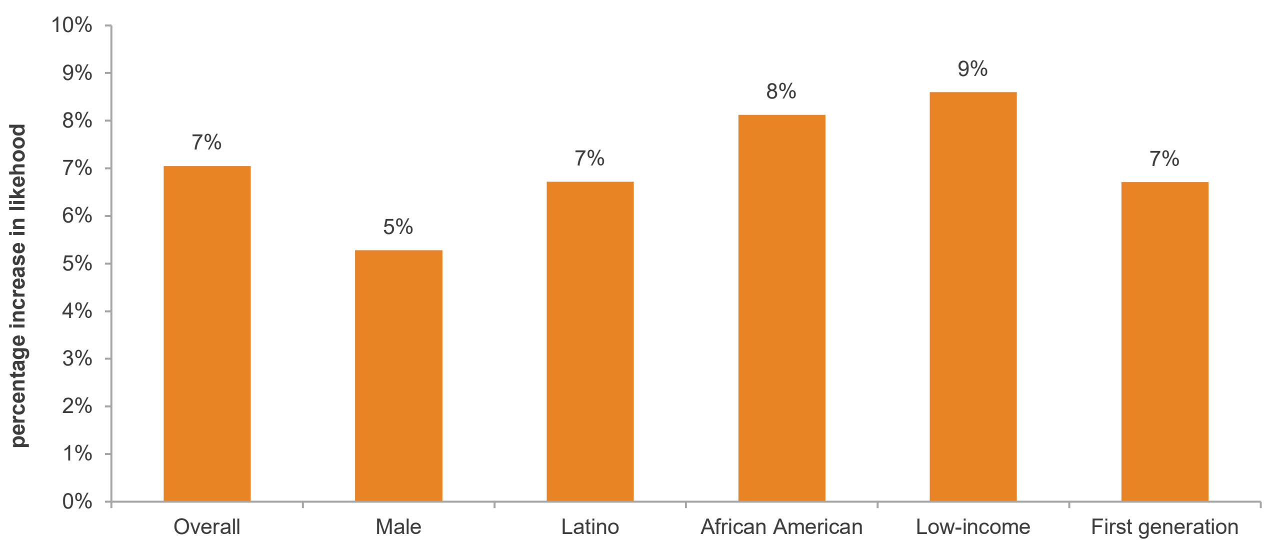
Students with Three or More Area D Are More Likely to Attend a Four-Year College

A key question to determine whether the policy would be right for California is this: does the extra year of science matter? According to our analysis, the answer is yes.[17] Completing three or more years of area D is associated with an increase in students' likelihood of attending a four-year college. However, it does not have any effect on the selectivity of the college, as measured by Barron's selectivity ranking (Technical Appendix C, Table 6). This may be because a minimum of three years of science is the *de facto* requirement of many four-year colleges.

The positive effects on four-year college enrollment are slightly larger among African American and low-income students, but lower among male students (Figure 9). Given that students with two years of area D have a reasonably high probability of taking another year, they could potentially benefit from the policy change, assuming they are successfully placed into an area D course. More research is needed to examine the effects of three or more area D on college persistence, GPA, and completion.

FIGURE 9

Graduates with three or more area D are more likely to attend a four-year college



SOURCE: Cal-PASS Plus, 2007–17.

NOTES: Each bar represents the linear coefficient of "three or more area D" on students' likelihood of attending a four-year college. Model controls for student demographics, low-income status, disability status, parental education, average GPA in area D courses, school fixed effects, and cohort fixed effects. Standard errors clustered at the high school level. All coefficients are significant at 1 percent level. For detailed model specification, please refer to Technical Appendix C, Table 6.

[17] We use our CPP sample to examine the effects of completing three or more years of area D on postsecondary outcomes. More details are included in Technical Appendix C, Table 6.

Are Schools Prepared to Offer Three Years of Science to All Students?

In theory the proposal could affect all high schools, as they will need to expand science offerings and encourage students to take more science courses. In this section, we examine the potential impact among two types of schools that may be more affected by the proposal: schools that currently do not offer three years (or more) of area D and schools that require A–G completion for high school graduation. Students in the former group may be negatively affected because their high schools do not offer enough area D courses; students in the latter group may not be able to graduate from high school if their schools align their local graduation policy with the new area D requirements.

Most High Schools Offer at Least Three Years of Science

During the 2017–18 school year, 9 percent (155) of public high schools did not offer at least three years of area D (Panel A, Table 2).[18] Most of these schools are alternative, community, or county schools serving special student populations. Only 44 regular high schools did not offer at least three years of science and most of them are charter schools. Statewide, the offering rate is not significantly different among high-need schools.[19]

The area D offering rate is higher among schools that require A–G for graduation (i.e., high standards schools). About a third of small high schools did not offer three years or more area D. Since they serve less than 1 percent of the state's population, we weight each school by their enrollment size and report the weighted offering rate in Panel B, Table 2.

TABLE 2

Few high schools did not offer three years of area D (or more), 2017–18

% schools offering…	Overall	High need	Large	Small	Urban	Rural	Charter	High standards
Panel A: unweighted								
<3 years of area D	9%	11%	0%	31%	8%	8%	10%	6%
Panel B: weighted by student enrollment								
<3 years of area D	2%	2%			0%	2%	4%	1%
N schools	1,752	1,133	103	354	724	178	408	610

SOURCES: UC A–G course management portal (CMP), 2017–18; California Department of Education, 2017–18; National Center for Education Statistics, 2014–15; PPIC Next Generation Science Standards Survey, 2018.

NOTES: Schools with high standards require A-G completion for high school graduation. Sample excludes high schools that cannot be matched to the California Department of Education's public school database file. Most of these schools are private high schools. CMP does not include all public high schools in California. In 2017–18, 805 active regular high schools were not included. Most (221) of these schools are charter schools; 72 are traditional public schools. High-need schools are those where at least 55 percent of students are low-income, English Learners, or foster youth. Large schools are those at the 90th percentile of the enrollment distribution (>2,663 students). Small schools are those at the bottom 10th percentile of the enrollment distribution (<198 students). Enrollment size and geographic locations are significant in a multi-variate framework. More details about the share of high schools offering 2, 1, or 0 area D are included in Technical Appendix C, Table 8.

[18] The number increased from 9 percent in 2007 to 14 percent in 2013 and then decreased to 9 percent in 2017. For more details, please refer to Technical Appendix C, Table 3.

[19] Defined here as schools in which at least 55 percent of students are low-income, English Learners, and/or foster youth.

Table 3 details the offering rate for each science course. Biology, chemistry, and physics are the most popular area D courses. Integrated science—introduced by NGSS (2013)—is gaining popularity over time: 16 percent of high schools offered them during the 2017–18 school year. The offering rate is lower among high-need and small schools, which are more likely to face capacity constraints. Only 62 percent of small schools offered area D physics, substantially lower than the statewide average (84%). There is no meaningful difference by school's geographic location or charter school status.

Physical science—56 percent of which is earth science (ES)—is the most popular science elective (offered in 60% of schools), followed by biological science (43%), and integrated science (31%). Schools tend to offer different electives based on their geographic location, school size, and charter school status. High schools that require A–G completion for graduation are less likely to offer physical science electives. This may be offset by the fact that more of their earth and space science courses are area D approved. The offering rate is much higher among small schools but lower among large, rural, and charter schools. Weighted offering rates are included in Technical Appendix C, Table 9.

TABLE 3

Percent of high schools offering selected science courses, by school characteristics, 2017–18

% schools offering...	Overall	High need	Large	Small	Urban	Rural	Charter	High standards
Area D:								
Biology	98%	97%	100%	93%	98%	98%	97%	99%
Chemistry	91%	90%	100%	75%	92%	94%	91%	95%
Physics	84%	81%	100%	62%	85%	84%	81%	83%
Earth and space science	14%	15%	23%	13%	13%	15%	19%	51%
Area G:								
Physical science	60%	59%	86%	51%	61%	56%	48%	36%
Biological science	43%	41%	65%	19%	41%	39%	27%	45%
N schools	1,752	1,133	103	354	724	178	408	461

SOURCES: UC A–G course management portal (CMP), 2017–18; California Department of Education, 2017–18; National Center for Education Statistics, 2014–15.

NOTES: Sample excludes high schools that cannot be matched to the California Department of Education's public school database file. Most of these schools are private high schools and charter schools. CMP does not include all public high schools in California. In 2017–18, 805 active regular high schools were not included. Most (221) of these schools are charter schools; 72 are traditional public schools. High-need schools are those where at least 55 percent of students are low-income, English Learners, or foster youth. Large schools are those at the 90th percentile of the enrollment distribution (>2,663 students). Small schools are those at the bottom 10th percentile of the enrollment distribution (<198 students).

Teacher Staffing Difficulties More Prominent in High-Need Schools

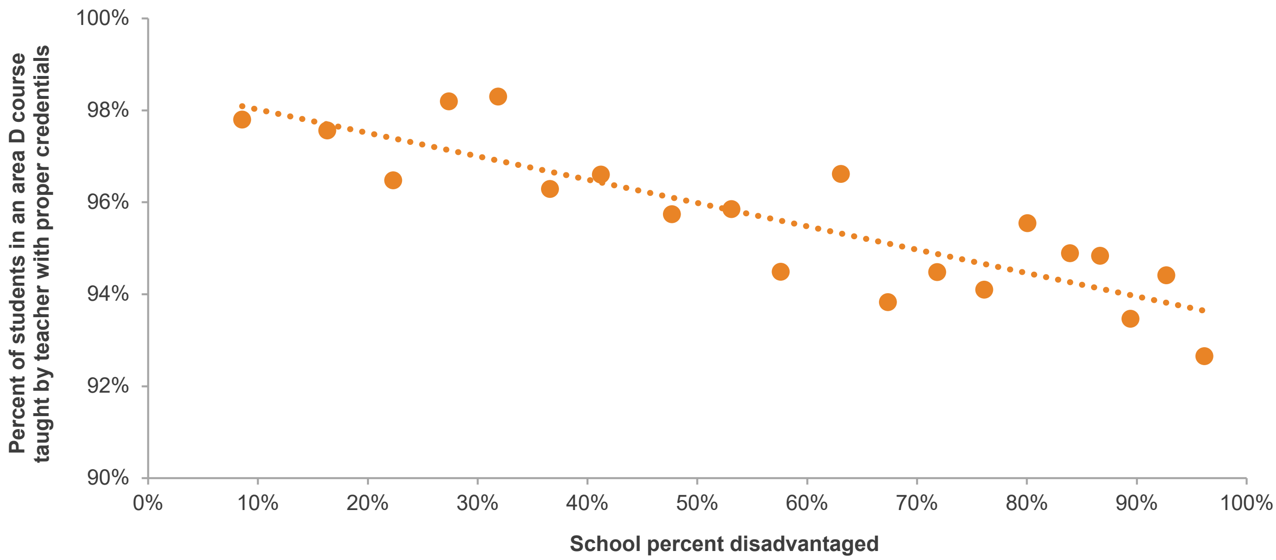
One critical concern is whether high schools—particularly high-need high schools—have the capacity to accommodate the increased demand. Although most students who are currently UC eligible take three or more years of area D courses and will be unaffected, any increase in UC requirements is still likely to incur an increase in demand. This increase is likely to be greater in higher-need schools, as students in such schools are more likely to have only taken two area D science courses than those in lower-need schools (Figure 2). It is therefore important to consider the extent to which schools currently have the capacity to meet increased demand, and whether this differs by the share of high-need students enrolled in a school.[20]

Overall, roughly 95 percent of students in A–G biology, chemistry, or physics courses are taught by a teacher with proper credentials (Figure 10).[21] [22] This ranges from about 93 percent in the highest-need schools to nearly 98 percent in the lowest-need—or most affluent—schools. Importantly, improper teacher credentials are not an issue for most students in area D science courses, but schools may still have difficulty staffing these positions.

Indeed, although this is not an issue for most *students*, nearly half of *schools* in the state have at least one biology, chemistry, or physics classroom led by a teacher not credentialed in that subject (Figure 11). This mismatch is more prominent among schools that serve higher-need students. Roughly 70 percent of lower-need schools have no classrooms with subject-credential mismatch in these courses, but nearly half of high-need schools have at least one. These high levels of mismatch indicate that many schools—particularly those serving more disadvantaged students—currently have difficulty staffing A–G science courses.[23]

FIGURE 10

Nearly all students in an A–G biology, chemistry, or physics course are taught by teachers with proper credentials



SOURCES: California Department of Education; authors' calculations.

NOTES: Each dot/bin includes multiple schools and represents an equal number of schools. Dashed line shows the best linear fit.

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[20] To do so we used publicly available staff data from the California Department of Education, which include detailed information on staff assignment (e.g., A–G courses) and credentials (e.g., physics).

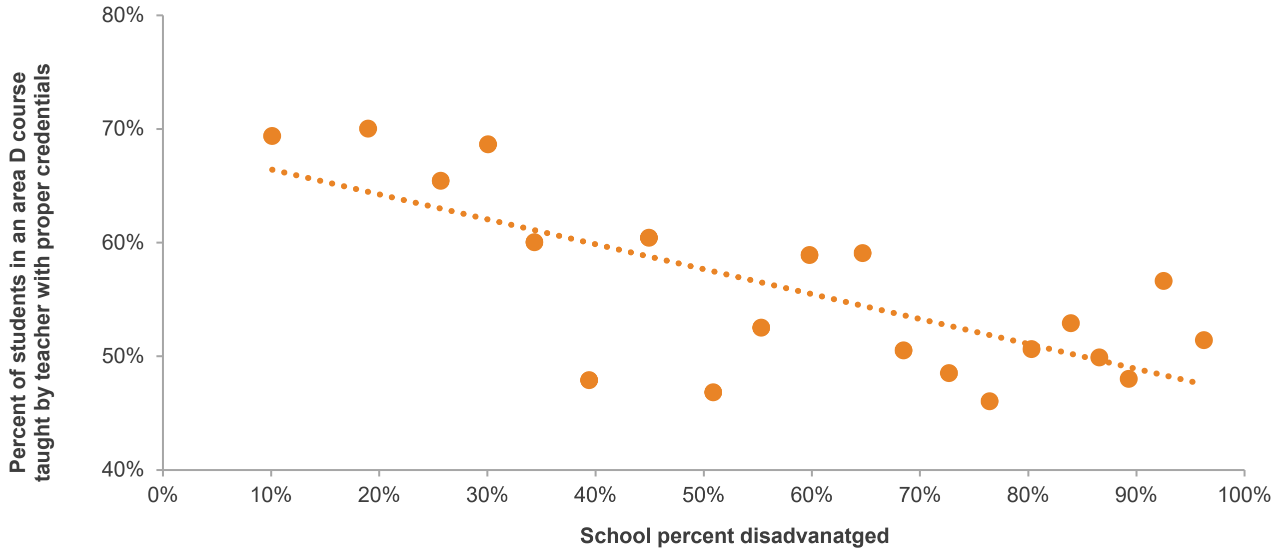
[21] Unfortunately, we do not have a direct indicator of area D certification for courses in the CDE staff assignment files, and instead restrict attention to only those biology, chemistry, and physics courses that meet area A–G requirements.

[22] We define "proper credentials" to mean that the teacher is certified in science and holds either a primary or secondary certification in the specific subject they are teaching.

[23] See Darling-Hammond et al. (2018) for a more detailed overview of the current staffing difficulties facing high-need schools.

FIGURE 11

Nearly half of high-need schools have at least one area D biology, chemistry, or physics course taught by teacher with improper credentials



SOURCES: California Department of Education; authors' calculations.

NOTES: Each dot/bin includes multiple schools and represents an equal number of schools. Dashed line shows the best linear fit.

High-need schools are also more likely to rely on novice teachers to teach A–G science courses (Technical Appendix C, Figure 2). Although less than 20 percent of A–G science teachers are novice (defined here as having three or fewer years of experience) in low-need schools, this increases to around 35 percent in the schools with the greatest share of high-need students. Insofar as teachers are initially less effective, these disparities raise concerns about the instructional quality in science courses in high-need schools. Efforts to expand science eligibility requirements for admission into UC could potentially exacerbate these inequities, as increased demand for science teachers across the state without any commensurate increase in supply could lead to more experienced and qualified educators being "poached" from higher-need schools by more-affluent schools and districts.[24]

High Schools Need to Improve Access to A–G Courses

To improve student access to A–G courses, high schools need to implement a comprehensive course scheduling, counseling, and placement system in parallel with expanding science course offerings. All high schools in our TES sample offered at least three years of area D, yet 24 percent of the graduates and 19 percent of the A–G graduates completed only two years. Many of these students are academically prepared but are not always placed into an area D science course. For instance, nearly half of the affected graduates were ready to take an area D course in 12th grade, but only a quarter of them were placed (Figure 8).

Existing research suggests that low-income and minority students lack access to guidance counseling, and are more likely to be placed into a lower-level class for the non-college-bound.[25] Some high schools rely on teacher recommendations, which may be a further barrier because teacher referrals are biased against low-income, minority, English Learners, and girls (Riegle-Crumb and Humphries 2012; Card and Giuliano 2016). In recent

[24] A similar staffing pattern appeared to take place following the California class size reduction of the late 1990s: a statewide increase in demand for teachers resulted in more experienced and qualified teachers leaving from higher-poverty to lower-poverty schools and districts (Jepsen and Rivkin 2002).

[25] Lee and Ekstrom (1987); McKillip, Rawls, and Barry (2012); Bryan et al. (2011); Oakes and Guiton (1995); Klopfenstein (2004); Handwerk, Tognatta, Colley, and Gitomer (2008).

years, some districts, such as Florida's Broward County Public Schools, Miami-Dade County Public Schools, North Carolina's Wake County Public Schools, and Sacramento Unified School District have implemented policies that automatically place students into different educational programs based on objective criteria. Early evidence suggests that such a placement policy is effective in increasing the representation of low-income and minority students (Card and Giuliano 2016; Dougherty et al. 2017).

Conclusion

In an effort to align its college admission requirements with the new K–12 science standards, UC recently proposed to increase its area D requirements from two to three years. UC's new policy has the potential of improving student science learning and readiness for college, but could reduce eligibility and have negative effects on equity.

In this report we examined how schools and students may fare under the new proposal. During the 2017–18 school year, 19 percent of the A–G graduates in our sample completed only two years of science and may be affected by the new proposal. The number is higher among Latino (23%) and African American (23%) students but a lot lower among white (12%) and Asian American students (10%).

Compared to graduates who have completed at least three years of science, students who may be affected tend to start the sequence late (i.e., in 10th grade). They are also less likely to be placed in area D science beyond 10th grade, despite being well prepared. Our transcript analysis suggests that A–G course criteria play an important role, as affected students are much more likely to be placed in science electives—most of which are earth science—instead of an area D course. Institutional factors such as teacher staffing, course scheduling, course placement, and counseling are also key to improvement.

Recommendations

At the University of California:

Expand the list of area D courses to include science electives beyond earth science. The recent decision from the BOARS to allow certain area G courses (e.g., computer science) to count toward area D completion is encouraging, and UC should make sure that all high schools are aware of the change. Earth science is the most popular science elective and many students are being placed there rather than area D science. Moving all earth science into area D would substantially mitigate the effects on eligibility. Further expanding area D to include all science electives would reduce the number of affected students by nearly half. This expansion especially mitigates the negative effects on Latino and African American students.

Engage in vigorous statewide outreach to inform students, families, school counselors, and teachers about the change, preferably before ninth grade. Information about the benefits of a third year of science (particularly for students not interested in STEM majors) and effective communication with schools, counselors, parents, and students will be critical to the awareness campaign. UC should also collaborate with the CDE and/or the County Offices of Education to discuss options for non-offering and high-need schools. Several programs, such as UC Scout, which delivers A–G classes online, may be helpful in addressing the capacity issues in these schools.

Include a phase-in period to closely monitor high schools' responses and address equity implications before full implementation. Since it takes time for schools to augment and submit their area G science courses for area

D approval, a phase-in period will give high schools time to adjust course schedules and find additional faculty if necessary. UC needs to monitor the number *and* type of high schools that have submitted their science electives to area D, so no high schools will be disproportionately affected by the change. A better integration of UC's A–G data portal and the CDE's CALPADS course reporting system will be useful to monitor the transition.

At high schools:

- **Submit earth science courses to area D.** High schools need to revise their earth science coursework and submit it for area D approval. The low-cost policy change would make it easier for students to complete the new requirements. It also benefits Latino and African American students more.
- **Review and revise their course placement and counseling policy.** High schools should review and if necessary, revise their course placement, grading policies, and validation rules to ensure that all academically prepared students are enrolled in area D courses. One option is to default these students into area D courses so students would have to opt out of (as opposed to opt in to) area D science.

At the state level, policymakers including the Commission on Teacher Credentialing, the governor's office, and the Legislature:

- **Allow science teachers to teach certain computer science courses.** Effective 2019–20, computer science courses are allowed to count toward area D completion; however, science teachers (with single-subject credential) are not authorized to teach computer science without a supplemental authorization or taking additional college-level coursework. Because some of the NGSS guidelines overlap with those in the K–12 computer science standards, allowing science teachers to teach computer science could support the integration and implementation of both standards; it could also support the implementation of the new area D proposal by increasing the course options for students.
- **Increase efforts to prepare, recruit, and retain science teachers.** The governor's 2019–20 budget included $147 million in state and federal funds for teacher workforce development. CSU has also committed to increase the annual output of qualified math and science teachers by one third (EdSource 2019). The new investments may help to alleviate districts' staffing difficulties and may allow districts to increase science course offerings, particularly in higher-need schools with lower offering rates. Additional policy efforts to promote the retention of science teachers—particularly in high-need schools—would also help to address existing inequities (Carver-Thomas and Darling-Hammond 2017).
- **Monitor the implementation closely to address any potential adverse effects on equity.** Future research should leverage a more comprehensive database to examine the effects of a third year of science on college performance, persistence, and completion. It should also unpack student decision-making processes and examine whether and how the new proposal may change their decisions on taking courses, college application, and college enrollment.

Improving science literacy and skills is an important lever to expand educational opportunity and improve student outcomes. The new science requirements could potentially improve learning for science students in high schools and hence readiness for college. However, as with any educational policy, local implementation is key to the success of the proposed policy. The equity implications should be at the front and center of any policy efforts to address the persistent achievement gaps.

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