

Passing challenging introductory chemistry course gives biggest boost to underrepresented students

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Studies have shown that students from certain backgrounds are less likely than their peers to complete an undergraduate degree in science,

technology, engineering or mathematics—or STEM. These groups are low-income students, first-generation college students, female students and students from underrepresented minority backgrounds: Latinx, African American, Native American and Native Hawaiian and Pacific Islander.

A new study out of the University of Washington shows that general chemistry—a key introductory-level course series for many STEM degrees—is a major barrier for underrepresented students. In a paper published June 10 in *Science Advances*, researchers report that they examined 15 years of records of student performance, education and demographics for chemistry courses at the UW. They found that underrepresented students received [lower grades](#) in the general chemistry series compared to their peers and, if the grade was sufficiently low, were less likely to continue in the series and more likely to leave STEM.

But if underrepresented students completed the first general chemistry course with at least the minimum grade needed to continue in the series, they were more likely than their peers to continue the general chemistry series and complete this major step toward a STEM degree.

"General chemistry is often the first science course that many would-be STEM majors take in college, and it has a brutal reputation for causing lots of attrition," said senior author Scott Freeman, a UW principal lecturer emeritus of biology. "When we examined this large dataset, we discovered that not only is this true, but it is having a disproportionately negative impact on underrepresented students, and likely contributes to lower diversity in STEM fields."

Chemistry is the study of matter—focusing on the structure, properties and behavior of atoms and more complex compounds. It is its own scientific field, and also a foundational subject for many other scientific disciplines—including biology, medicine and engineering. At many

colleges and universities, before would-be doctors can take a biology course, they must pass general chemistry courses, which usually last a year.

Under the UW's quarter system, the general chemistry series consists of three courses. At universities with a semester system, the series is often two.

For the first course in the UW general chemistry series, the team found that [grades](#) for underrepresented students were lower on average than their peers, ranging from 0.13 grade points lower for female students to 0.54 grade points for students from underrepresented minority backgrounds.

Students enter college with different levels of preparation. When the researchers controlled for this by factoring in high school grade-point averages and SAT scores, the gap narrowed for all groups. For example, the gap narrowed to 0.16 grade points for students from underrepresented minority backgrounds. But for no group did the gap disappear, and the team saw similar patterns for the rest of the general chemistry series.

"The fact that the gap persists even after we correct for different levels of academic preparation means that something else is going on—something that is actively penalizing underrepresented students in general chemistry," said Freeman.

The grade gap has consequences. In the UW and many other institutions, students must receive a minimum grade, often a C-minus or equivalent, in the first general chemistry course in order to take the next one. The team found that underrepresented students receiving a grade lower than the minimum—a D or F—were less likely than their peers who received the same grade to retake the course and thus continue in STEM.

But, the team also discovered that students from underrepresented groups are what Freeman calls "hyperpersistent." Underrepresented students who received a C-minus or better in the first general chemistry course were more likely than peers who received the same grade to continue the series.

"Underrepresented students are showing resiliency, if they can meet that minimum threshold," said Freeman.

For the study, the researchers examined records from 25,768 students who took UW chemistry courses between 2001 and 2016. These included both general chemistry and organic chemistry, a more advanced year-long course series that follows general chemistry and is required for many STEM degrees in chemistry, health and medicine. The team saw similar, but smaller, disparities in grades and passing rates for underrepresented students in organic chemistry.

Now that the team has identified a major reason that fewer underrepresented students continue in STEM, Freeman and his colleagues want to understand why. One major reason may be teaching methods. During the study period, both general chemistry and organic [chemistry](#) were taught using traditional, lecture-based formats. Freeman and his team have previously shown that so-called "active learning" methods create more inclusive learning environments and boost student performance in STEM courses. These techniques often rely on discussions and problem-solving approaches, and disproportionately benefit underrepresented students.

There are likely other factors, including larger socioeconomic and cultural issues, said Freeman. But the hyperpersistence the team discovered, if confirmed by other studies, may offer a path forward.

"It may be that if you can make changes to coursework and learning that

boost [student](#) performance—that help underrepresented students get at least that minimum grade to keep going—they can do it," said Freeman. "These students can do the hard work. They have what it takes."

More information: R.B. Harris et al., "Reducing achievement gaps in undergraduate general chemistry could lift underrepresented students into a 'hyperpersistent zone'," *Science Advances* (2020). DOI: 10.1126/sciadv.aaz5687 , advances.sciencemag.org/content/6/24/eaaz5687

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