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Gender Gap in Physics Exams Reduced by Simple Writing Exercises, Study Finds

Women are underrepresented and on average perform more poorly than men in introductory physics. But a recent study finds that this gap arises predominantly from differential preparation prior to college and psychological factors, rather than differences in ability.

And the effects of these psychological factors can be largely overcome with a brief writing exercise focusing on important values, such as friends and family, learning or even music. This simple "values affirmation" writing exercise generally raised women's course grades from the "C" to "B" range, a study led by University of Colorado at Boulder researchers has found.

These self-affirming essays, the researchers suggest assuaged women's stress about being seen in light of negative stereotypes about women in science. Besides getting better grades, the women also showed greater mastery over the conceptual material, the team found.

Further, the positive effects of values affirmation are most pronounced among women who tended to believe in the stereotype that men are better than women at physics.

Those are key findings of a study published in the Nov. 26 edition of Science. Five of the study's authors are at CU-Boulder and one is a former CU researcher now at Stanford University.

"I just wasn't expecting this kind of finding," said Akira Miyake, a CU-Boulder professor of psychology and neuroscience and lead author on the Science paper. As Miyake noted, the students in the study were all majors in so-called STEM disciplines -- Science, Technology, Engineering and Mathematics.

"They're already interested in these things and are highly motivated to do well in that course," he said. "It still amazes me that this writing exercise has such positive influences."

Miyake led the team of researchers -- three from psychology and three from physics -- who applied recent psychological research on "identity threat" to women in a challenging physics course.

Tiffany Ito, associate professor of psychology and neuroscience and co-author of the study, notes that the common expectation that men do better in physics than do women is an "identity threat" that can undermine women's ability to reach their full potential.

Women are aware of the stereotype and might worry that their performance in a physics class will confirm the stereotype.

"That creates some fear, stress and anxiety," Miyake said. "It's especially bad during exams" when the stakes are high and they know they are being evaluated. The anxiety might distract women from the course material, he said.

Women, who constitute a minority of physics students, also are affected by external cues, Ito added. "Those women are sitting in a class consisting of predominantly men, and they might wonder if the men buy into the stereotype and think they're better at physics."

However, "The research shows that if we affirm people's self integrity, you buffer them from other threats," Ito said.

Geoffrey Cohen, a co-author of the study and a former CU psychologist, has studied this effect among ethnic minorities in middle schools. Cohen, now a professor in Stanford University's School of Education and the department of psychology as well as a courtesy professor at the Graduate School of Business, said the affirmation exercises can be powerful.

As Cohen explains, a values-affirmation exercise might prompt thoughts such as these: "'In spite of all the adversity in my environment, here is what I care about. Here's what gives me my internal compass. Here is what I stand for.' And that can be alleviating in a stressful

situation." What is not known, the psychologists emphasize, is exactly how values-affirmation exercises work or whether they will work in other physics or STEM courses.

The physicists also note that this research narrowed but did not eliminate the gender gap. Women generally enter college less prepared for college physics courses than men.

Lauren Kost-Smith, a co-author and a physics graduate student who has won the Chancellor's Award for Excellence in STEM Education, has done several studies of the gender gap in physics. She noted that for six or seven semesters, CU women completing conceptual-mastery tests in physics did consistently worse than did men, but factors such as prior course work and demonstrated aptitude did not fully account for the difference.

In CU's randomized double-blind experiment, 399 students, including 283 men and 116 women, were randomly assigned writing assignments that either affirmed their values or did not. Students completed the writing exercises twice, in the first week of the semester and during the week preceding the first mid-term exam.

Students in the "affirmation group" were given a list of 12 values, such as "relationships with friends and family" or "learning or gaining knowledge," and were asked to write about the values most important to them.

The remaining students in the "control" group were asked to pick values on the list that were least important to them and to write about why those values might be important to other people.

"Thus, both groups wrote about values and their importance, but the exercise was self-relevant only for the affirmation group," the authors write.

Additionally, the team measured how much each student embraced the gender stereotype. As part of an online survey given early in the semester, students were asked to rank their agreement (from "strongly disagree" to "strongly agree") with this statement: "According to my own personal beliefs, I expect men to generally do better in physics than women."

Among the women who more strongly endorsed the stereotype, women in the affirmation group obtained higher course grades and showed better conceptual mastery of physics than women in the control group who also agreed with the statement.

Men's grades and conceptual mastery were not significantly affected by the values-affirmation exercise.

Steven Pollock, professor of physics and a CU President's Teaching Scholar, noted that the study funded by the National Science Foundation is a "small piece" of a large puzzle, and he and his colleagues stressed that the results are no silver bullet in STEM education.

While concurring, Noah Finkelstein, a co-author and associate professor in physics, added, "This is a really exciting finding. It bears further exploration. These results hold significant promise for addressing differential performance and the significant disparity of recruitment and retention of women in STEM disciplines."