



Succeeding but Doubting: Effects of Gender on Performance and Self-perception in Early Engineering Courses

Dr. Jennifer Blue, Miami University

Jennifer Blue is an Associate Professor of Physics at Miami University. She works to give more people access to physics. Sometimes that's reforming the curriculum for introductory classes, sometimes it's working with K-12 science teachers, and sometimes it's advocating for traditionally excluded populations, including women in STEM. Her website can be found here: <http://www.users.miamioh.edu/bluejm/>.

Dr. Amy Summerville, Miami University

Dr. Summerville is an Associate Professor in the Department of Psychology at Miami University. She earned her Ph.D. in Psychology from the University of Illinois at Urbana-Champaign. Dr. Summerville is a social psychologist whose research examines how thoughts of "what might have been" affect emotion, motivation, and behavior. She is the PI of a grant from NSF's EEC division investigating new interventions in engineering education that utilize social cognitive psychology.

Dr. Brian P. Kirkmeyer, Miami University

Brian Kirkmeyer is the Karen Buchwald Wright Senior Assistant Dean for Student Success and Instructor in the College of Engineering and Computing at Miami University in Oxford, Ohio. His background includes BS, MS and PhD degrees in Materials Science and Engineering (specialization in polymers), the former from Purdue University and the latter two from the University of Pennsylvania. He has work experiences in automotive electronics (Delphi Automotive Systems) and consumer products (International Flavors and Fragrances) prior to his current role. He served on the executive committee of the ASEE Women in Engineering division from 2010 to present.

Ms. Brielle Nikole Johnson

Brielle Johnson is a graduate student in the Social Psychology program of the Department of Psychology at Miami University. She earned her B.S. from Grand Valley State University with a double major in Psychology and Sociology. Her research interests include issues related to social class and gender, as well as areas of existential psychology and counterfactual thinking.

Succeeding but Doubting: Effects of Gender on Performance and Self-perception in Foundational Courses for Engineers

Jennifer Blue, Amy Summerville, Brielle Johnson, and Brian Kirkmeyer¹

Two studies were done with engineering majors enrolled in three courses taken in their first year of college: calculus-based physics, calculus, and introductory computer programming. The first study was of 75 men and 45 women and the second study was of 154 men and 80 women. Although women in Study 1 had a lower score on their first exam, this was not true in Study 2, nor were course grades for men and women different in either study. Men and women in both studies also had equivalent mindsets. However, women in both studies had lower efficacy than men did, and women in Study 1 felt more affective (but not cognitive) regret after their first exam.

I. Introduction

In the past 5 years, about 30% of students in a calculus-based physics course required of all entering students in the engineering division at a university in the Midwest earned a grade of a D or F or withdrew (DFW) from the course. Such high “DFW” rates pose a tremendous challenge to student pathways through engineering programs, potentially delaying the time to degree, imposing financial burdens on students and families, and contributing to attrition from the major into non-STEM fields. Improving student success in early courses within the engineering major would therefore address a critical issue in engineering education.

Women in engineering are of particular concern. In 2013, women were 19.2% of undergraduate engineering majors in the US [1]. That same year, they held 26% of the jobs in computing and only 12% of the jobs in engineering [2]. In this study, we examine the effects of gender on the performance of students in early courses that engineering majors take during their first year of college. We also examine effects of gender on student mindset, self-efficacy, and on the regrets that they may feel after they take their first exam. These measures of self-perception often have enough of an effect on students that they affect student performance and persistence in a major and, sometimes, in a career.

A. Mindset

People can have either fixed or growth mindsets. Someone with a fixed mindset believes that intelligence is both stable and uncontrollable, while someone with a growth mindset believes that intelligence can improve [3]. Students with fixed mindsets may interpret one low exam grade as evidence that they are not smart enough to learn the material in a course, while those with growth mindsets are more likely to keep trying to learn. Consequently, people with

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growth mindsets are more likely to experience academic success [4], especially in STEM courses [5].

Much of the gender research on mindset has been done with girls and boys who are younger than college students. Girls have been shown to suffer because of teachers who seem to have fixed mindsets, self-selecting out of STEM if they do not think they are smart enough [6]. However, middle school girls with a growth mindset closed the gender gap on achievement tests in mathematics [6].

B. Efficacy

Self-efficacy is the belief a person has about their ability to do something. Someone's self-efficacy may be different in different situations; for example, someone might have a high self-efficacy with respect to swimming but not with respect to calculus [7]. Self-efficacy is often correlated with other factors of stress, effort, resiliency, and self-blame [7]. Those with higher self-efficacy are more likely to persist and be retained in their academic programs [8] and more likely to receive higher grades [8, 9].

Many studies of gender difference in self-efficacy have been done with K-12 students. Several studies have found that boys have higher self-efficacy in both computing and mathematics [10]. These gender differences were larger for older children than for younger ones [10], suggesting that they might be high among college students.

C. Regret

Regret is an emotion driven by thoughts of "what might have been" [11]. While these thoughts are often negative and can be unpleasant, they often do lead to positive changes in future decisions [12, 13]. Research on regret has found few gender differences in what people regret [14], with exceptions in the areas of sexual activity [15]. In this study, we look for gender differences in student regret after engineering majors take their first physics exam in college.

II. Methods

A. Participants

The participants were students at a midsized state university in the Midwest. They were engineering majors enrolled in required prerequisites for engineering. In study 1, all of the participants were enrolled in a calculus-based physics course. In study 2, participants were enrolled in either that same physics course, a calculus course, or an introductory computer science course. They were contacted during the first three weeks of the semester and invited to participate in a series of surveys. They were paid for their time. Their first survey was done at the start of the semester, and they were also surveyed after they had their first exam returned to them. Additionally, the students gave us a FERPA release so that we could ask their instructors for their course grades. In the first study, we had 120 students who reported their gender in the surveys; 75 men and 45 women. In the second study, we had 234 students who reported their gender: 154 men and 80 women.

B. Materials

1) *Mindset*. The student survey about mindset is seen in Appendix A. This survey consists of three items, such as “Your intelligence is something about you that you can’t change very much [16]”, which students respond to on a seven-point Likert scale with options “Strongly disagree”, “Disagree”, “Somewhat disagree”, “Neither agree nor disagree”, “Somewhat agree”, “Agree”, and “Strongly agree”. The students did the mindset survey at the start of the semester and, on study 2, also after their first exam was returned.

2) *Efficacy*. The student survey about efficacy is seen in Appendix B. This survey used seven items to gauge student beliefs about their ability to succeed in the course, such as “I feel like I can successfully complete the course with a C or higher” or “I’m thinking of dropping the course” (reverse-scored). Students were asked to think about the course at the time of the survey and respond to each of the items on a seven-point Likert scale with options “Strongly disagree”, “Disagree”, “Somewhat disagree”, “Neither agree nor disagree”, “Somewhat agree”, “Agree”, and “Strongly agree”. The students did the efficacy survey after their first exam was returned.

3) *Regret*. The student survey about regret is seen in Appendix C. Students were given the prompt, “We’d now like you to focus on your feelings about the first exam in PHY 191. Please indicate how much you agree with each statement as it describes how you feel about the first exam right now, at the present moment. There were ten items on the survey. Five of these items, such as “I feel like kicking myself”, dealt with affective regret, while the other five, such as “Things would have gone better if I had chosen another option”, dealt with cognitive regret [18]. Students responded to each item with seven-point scales with Likert response options “Strongly disagree”, “Disagree”, “Somewhat disagree”, “Neither agree nor disagree”, “Somewhat agree”, “Agree”, and “Strongly agree”. The regret survey was on the post-exam survey. The students did the regret survey after their first exam was returned.

III. Results

A. Performance

1) *Score on the first exam*. Students reported their own exam scores after they were returned. Women had lower scores than men did on their first exam in study 1, but not in study 2. In the first study, the mean score for women was 64.55% with a standard deviation of 19.89, and the mean score for men was 74.31% with a standard deviation of 20.61. This was a statistically significant difference: $t(76) = 2.26$, $p = 0.03$. In contrast, women and men had equivalent exam grades in study 2 [Means (s.d.) = 63.48 (20.21) vs. 67.98 (19.80), respectively, $t(176) = 1.45$, $p = .15$]. These results are included in Table 1.

| | | | | | | | | | |
|------------------|-------------------|------------------|--------------|----------------|----------------|-------------|------------------|------------------|------|
| Score on Exam 1 | 64.55% (19.89) | 74.31 (20.61) | 0.03 | | | | 63.48 (20.21) | 67.98 (19.80) | 0.15 |
| Course grade | 2.61 (0.91) | 2.64 (1.05) | 0.90 | | | | 2.53 (1.16) | 2.51 (1.28) | 0.90 |
| Mindset | 3.06 (1.36) | 2.95 (1.57) | 0.65 | 3.16 (1.37) | 3.35 (1.53) | 0.35 | 3.41 (1.61) | 3.34 (1.40) | 0.76 |
| Efficacy | 4.41 (1.07) | 5.04 (0.87) | 0.006 | 5.62 (1.10) | 5.88 (0.99) | 0.07 | | | |
| Affective Regret | 3.19 (1.67) | 4.45 (1.65) | 0.002 | 3.70 (1.71) | 4.03 (1.69) | 0.20 | | | |
| Cognitive Regret | 4.41 (1.59) | 4.81 (1.30) | 0.26 | 4.54 (1.43) | 4.89 (1.34) | 0.12 | | | |

Table 1: Results from both studies.

IV. Conclusion

We looked at the effects of gender on both performance and perception. We do want to acknowledge here that a binary view of gender is quite possibly over-simplistic, as students may have a wide range of gender identities [19]. On our intake surveys, we only did offer binary options for gender: male, female, or the third option of “other / decline to answer”. However, we believe that our comparison of students who identify as women to students who identify as male can still be useful to our colleagues in the Women in Engineering Division of the ASEE.

Looking at performance, we see that although women in the first study had a lower self-reported score on their first exam, this was not true in the second study, nor did women in either study have different final course grades than the men in their classes. Women also had the same mindset as men did in both studies. Previous research [6] has indicated that having a growth mindset can help students; perhaps the equivalent mindset between the men and women contributed to their equivalent exam and course grades.

Although this is comforting for those who want to see more gender parity in engineering majors, there were still some concerns. Women had lower efficacy in study 1 and in study 2 - as predicted by previous research [10]. This is concerning, as efficacy has been shown to predict retention above and beyond interest and performance [8, 9].

When we look at measures of regret, we see that women and men had equivalent scores on the cognitive regret scales in both studies. However, women had more affective regret than men did in study 1, but not in study 2. Affective regret links to negative psychological experiences like depression and anxiety, which is not what we wish for our majors. Further, in study 2, grade and gender interacted so that women with median exam grades felt more affective regret (self-blame) about the exam than their male peers.

Longitudinal studies could follow students through their engineering programs. Things to look for would be whether mindset interacts with efficacy, grades, and retention; whether efficacy continues to predict performance in university engineering students; and whether women continue to experience more affective regret than men and, if so, if this has a deleterious effect on their retention as engineers throughout and beyond the major.

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Appendixes

Appendix A: Mindset Survey

We'd now like you to answer some questions about how you think and feel in general. Please indicate how much you agree with each statement. (Each item had 7 point scales with Likert response options "Strongly disagree", "Disagree"; "Somewhat disagree"; "Neither agree nor disagree"; "Somewhat agree"; "Agree"; "Strongly agree".)

- You have a certain amount of intelligence and you can't really do much to change it.
- Your intelligence is something about you that you can't change very much.
- You can learn new things, but you can't really change your intelligence.

Appendix B: Efficacy Survey

We'd now like you to tell us about how you feel you are doing in your physics course. Please indicate how much you agree with each statement as you think about the course right now, in the present moment. (Each item had 7 point scales with Likert response options "Strongly disagree", "Disagree"; "Somewhat disagree"; "Neither agree nor disagree"; "Somewhat agree"; "Agree"; "Strongly agree".)

- I am doing well in the course.
- I am doing poorly in the course.
- I feel like I can successfully complete the course with a C or higher.
- I'm not sure that I can pass the course.
- I'm thinking of dropping the course.
- It is possible for me to succeed in this course.
- I'm confident that I can get the grade I want in the course.

Appendix C: Regret Survey

We'd now like you to focus on your feelings about the first exam in PHY 191. Please indicate how much you agree with each statement as it describes how you feel about the first exam right now, at the present moment. (Each item had 7 point scales with Likert response options "Strongly disagree", "Disagree"; "Somewhat disagree"; "Neither agree nor disagree"; "Somewhat agree"; "Agree"; "Strongly agree".)

Affective regret (note that these headings did not appear in the survey)

- I am experiencing self-blame about how I did.
- I feel sorry.
- I am experiencing self-blame.
- I feel guilty.
- I feel like kicking myself

Cognitive regret (note that these headings did not appear in the survey)

- Things would have gone better if I had made different choices.
- I wish I had done something differently.
- I should have acted differently.
- I would have been better off had I done something differently.
- Before I should have done something differently.