2018 CoNECD - The Collaborative Network for Engineering and Computing Diversity Conference: Crystal City, Virginia Apr 29

# Beliefs and behaviors of first-generation and low-income students 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/.

**Brielle Johnson, Miami University**

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, as well as areas of existential psychology and counterfactual thinking.

**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.

# Beliefs and Behaviors of First-generation and Low-income Students in Early Engineering Courses

Jennifer Blue. Brielle Johnson, Amy Summerville, and Brian P. Kirkmeyer[1]

We investigated the beliefs and behaviors of both first-generation and low-income engineering majors as they were taking an introductory course required for their major. Of the 322 students at a mid-sized university who were surveyed, 18.3% indicated that they did not have a parent or guardian with a bachelor's degree, and 9.2% indicated that they had a family income of $50,000 or less, marking them as low income. Despite previous studies by others suggesting that these students would have different beliefs and behaviors than other engineering students, we found few differences.

First-generation college students and students from low-income families face a unique set of challenges in navigating the college experience. In addition to external obstacles, these students may also approach courses with a different internal landscape of beliefs about their ability to succeed in class. In the current research, we examined the thoughts, feelings, and behaviors of first-generation and low-income students in prerequisite and introductory engineering courses: calculus, physics, and computer science. There were not many of these students; 16.7% of students indicated that they did not have a parent or guardian who had completed a bachelor's degree or higher, and only 13.2% of students surveyed indicated that they had an annual family income of $50,000 or less. After a brief literature review, we will describe the participants, materials, and procedure before comparing the readiness, beliefs, achievement, and behaviors of both the first generation college students and low income students to their peers.

## I. Literature Review

External obstacles alone are insufficient in explaining a disparity in academic achievement between upper and lower income students. Not only do low-income and first-generation students encounter obstacles such as a lack of academic preparation and access to information about the college experience [1], but these students may also have internalized beliefs that hinder their academic achievements. A culmination of external and internal influences has resulted in a lack of representation of socioeconomically disadvantaged and first-generation students throughout academia [2]. Students' metacognitions about their abilities and feelings of affiliation with their institutions have been associated with academic performance. While there is much diversity within the population of low-income college students, there exist tendencies in metacognitions and feelings among this group that systematically operate to prevent academic success and retention in STEM fields. This lack of diversity can negatively impact innovation in STEM majors through a lack of diverse perspectives and untapped potential. The lack of low-income students in STEM is also problematic, since STEM careers are generally high paying; the continued education of certain groups of people at the exclusion

---

[1] Miami University, Oxford, OH This work is supported by NSF EEC Award 1530627.

of those from lower-income families intensifies the stratification of wealth in society [3]. This population of students from low-income families may also aid in overcoming a deficit growing in various STEM fields. The need for scientists is growing beyond the rate of scientists entering the career market, and the promotion of these underrepresented students may help fill this void [4].

The current research intends to predict the academic performance of early engineering majors based on student beliefs and feelings about their education in addition to academic preparation during high school. Prior research has demonstrated a correlation between low-income individuals and specific psychological beliefs that are relevant to student success: lower self-efficacy [5], fixed mindsets [6], and a lack of sense of belonging in academia [7] are all instrumental in understanding the underrepresentation of low-income students in STEM. Since first-generation students are also typically from low-income families, they share many of belief structures with other low-income students. However, there are certain differences between these groups that are important to highlight in understanding their obstacles towards academic success [8]. By identifying patterns of beliefs and preparatory behaviors, we will be better equipped to provide intervention tools that increase the presence of low-income and first-generation students in the field of engineering.

Students may enter college with different sets of beliefs about the university and their personal abilities to succeed. These distinct frameworks of thought may alter students' performance regardless of aptitude. Therefore, it is important to understand which beliefs are relevant to academic performance and how these frameworks of thought differ between advantaged and disadvantaged students. These beliefs that students have relevant to their education are related to academic performance. If disadvantaged students enter college with maladaptive beliefs, they may act as compounding obstacles in addition to financial strains and other external variables.

*A. Self efficacy*

Self-efficacy, or the beliefs about one's ability to successfully complete a task, is critical for student retention and persistence through adversity [9]. Even when an individual possesses the abilities necessary for success, their beliefs in personal capability to perform the task influence their actual performance [9]. These beliefs about ability are also associated with other factors of self-blame, stress, effort levels, and resiliency [10]. Those high in self-efficacy tend to have better grades and are more likely to excel academically and in their careers in comparison to individuals with low self-efficacy [9, 11]

Research in a Chinese population has demonstrated a positive correlation between social class and self-efficacy, such that individuals from low-income families tend to have lower self-efficacy than individuals from other income levels [5]. This tendency of lower self-efficacy among socioeconomically disadvantaged individuals may be relevant in understanding a lack of their representation in STEM majors. If they are unable to cope with these novel demands expected early in college, they may be less likely to persevere in their degree [12]. One explanation for lower self-efficacy among these groups is the presence of negative stereotypes associated with these groups; stereotypes may reduce self assessments of their compatibility with STEM based on their socioeconomic status, which could result in their diminished performance and ultimate avoidance of these majors.

*B. Growth mindset*

Another component of students' approach to education is their beliefs about intelligence; an individual with a fixed mindset perceives intelligence as a stable and uncontrollable trait. In contrast, someone with a growth mindset views intelligence as a malleable trait that has the potential to be improved [13]. While research has demonstrated that the ratio of students holding fixed versus growth mindsets is almost evenly split, growth mindsets are positively associated with academic achievement [14]. Individuals with a fixed mindset may have difficulty overcoming academic failures and utilizing in-depth learning strategies. Consequently, students with growth mindsets have been demonstrated to achieve higher grades in STEM related courses in comparison to those with fixed mindsets [15].

While the amount of mindsets among students generally is almost equal, low-income students are disproportionately more likely to have fixed mindsets [6]. These mindsets are related to how social classes distinctly perceive personal control; while lower class individuals tend to see external forces as determinants of success, upper class individuals often view their situations as the result of internal motivations and qualities. This type of perceived control leads low-income students to regard qualities such as intelligence to be externally regulated and unchangeable [16]. The issue of mindset is critical for understanding the disparity in academic achievement across social classes because of how mindset differentially impacts low-income students. While a fixed mindset was more debilitating for students from low-income families in comparison to students from other backgrounds, a growth mindset has the potential to drastically diminish the impact of other influences caused by socioeconomic disadvantages [6].

*C. Sense of belonging*

In addition to beliefs, students' feelings of belonging and acceptance in their college community are important in predicting their academic success. The need to belong and affiliate with others is a fundamental motivation, and this motivation influences various interpersonal behaviors [17]. Research conducted with elementary students has suggested that sense of school belonging is the most impactful contextual variable on classroom achievement, and belonging is positively correlated with academic self-efficacy [18]. In another study looking at women's persistence in engineering, rates of retention were associated with feelings of belonging to the major and the department [19]. A sense of belongingness often influences academic success indirectly through behaviors such as seeking external assistance or active engagement in the classroom [7]. Students' sense of affiliation with their university is important to their social and academic integration; these feelings are related to supportive interactions with peers and faculty. The likelihood of student retention increases when students are integrated in their social and academic communities, and when they feel that students with similar backgrounds to themselves belong in academia [20, 21]

While there are discrepancies in associative feelings between lower and upper income students and their universities [7,22], a lack of belongingness may be more prevalent in first-generation students. In comparison to continuing-generation students, first-generation students tend to be less integrated into the campus community [23]. They participate less in campus organizations and are more likely than their peers to be living off campus and working [24]. In general, both low-income and first-generation students are underrepresented in college populations, which often makes their backgrounds more salient to them. These thoughts about being different from other students may lead disadvantaged students to feel they do not belong in academia or STEM fields [25]. Disadvantaged students may develop internalized stereotypes based on their backgrounds that are inconsistent with an academic identity [2, 26]. This conflict between academia and self-assessments may hinder performance through feeling like they do not belong in their college environment.

*D. Communal goals*

Research, particularly in STEM fields, is dependent on collaborative efforts. However, STEM fields are often perceived as unsupportive of communal goals and prosocial objectives [27]. Career goals may be classified as either communal or agentic; communal goals are focused on others, while agentic goals are focused on the self. If a career is perceived as incongruent with an individual's orientation towards communal or agentic goals, they are less likely to pursue work in that area [28]. The issue of goal incongruity is problematic for the field of STEM and people who are highly communally oriented. When there are discrepancies between perceptions of a career and personal goal orientations, students are less interested in these careers and are less likely to pursue graduate education [4].

Individuals from low-income backgrounds typically have an interdependent self-construal that orients them to act in consideration of others and within contextual conditions. In contrast, individuals from middle-class backgrounds have a tendency towards an independent self-construal. This independent model of the self emphasizes ideals such as autonomy and self expression, and values of cooperation and reliance on others are promoted less [29]. These tendencies are largely a product of environmental factors that either provide or inhibit opportunities to act independently. When individuals have more economic and social resources, they are likely to have a more independent orientation [29].

The current research investigates these differences in beliefs, thoughts, and behaviors based on students' social class and whether they are first- or second-generation students. The intentions of the current study are to identify patterns between these groups and assess their impact on academic performance. Identifying patterns of students' behaviors and beliefs will enable more effective intervention efforts that focus on disadvantaged students. Through defining the differences in beliefs between students of different socioeconomic backgrounds, it is possible to better understand the discrepancies in representation.

## II. Methods

*A. Participants*

Students at a mid-sized state university in the midwest who were enrolled in calculus-based physics, calculus, and introductory computer science courses were contacted in the first month of the semester and invited to participate in a series of paid surveys. In the present research, we include only the 234 students (Age M (s.d.) = 18.63 (1.39); 154 male, 80 female; 191 white, 12 African American, 3 Native American, 31 Asian or Asian American; 13 Hispanic) who indicated that they were currently engineering majors or were undeclared but intended to major in engineering. 13.2% of students indicated that they had an annual family income of $50,000 or less. 16.7% of students indicated that they did not have a parent or guardian who had completed a bachelor's degree or higher.

*B. Materials*

*1) Efficacy*. Participants' beliefs about their ability to succeed in the course were measured with 7 items: "I am doing well in the course"; "I am doing poorly in the course" (reverse-scored); “I feel like I can successfully complete the course with a C or higher”[2]; “I’m not sure that I can pass the course” (reverse-scored); “I’m thinking of dropping the course” (reverse-scored); “It is possible for me to succeed in this course”; “I’m confident that I can get the grade I want in this course”. Participants were asked to indicate how much they agreed with each statement as they thought about the course “right now, in the present moment” and responded to each item with 7 point scales with Likert response options “Strongly disagree”, “Disagree”; “Somewhat disagree”; “Neither agree nor disagree”; “Somewhat agree”; “Agree”; “Strongly agree”. Alpha = .89 (intake); .93 (exam).

2) *Mindset*. Participants completed the three-item measure of fixed mindsets (e.g. “You have a certain amount of intelligence and you can’t really do much to change it”; [30]) using 7 point scales with Likert response options “Strongly disagree”, “Disagree”; “Somewhat disagree”; “Neither agree nor disagree”; “Somewhat agree”; “Agree”; “Strongly agree”. ; alpha = .91 (intake); .95 (exam).

*3) Belongingness.* A subset of participants completed two measures of belongingness: 5 items measuring fit (adapted from [31]) and the 18-item Perceived Sense of School Membership ([32] adapted to refer to the department of the course, rather than the school as a whole). The 23 items were presented in random order. Participants were asked to indicate how well the statements described how they felt about the students, faculty, and staff in the Department of Physics or the Department of Computer Science and Software Engineering “right now” and responded to each item with 7 point scales with Likert response options “Strongly disagree”, “Disagree”; “Somewhat disagree”; “Neither agree nor disagree”; “Somewhat agree”; “Agree”; “Strongly agree”. Because the items were highly consistent, the two measures were averaged into a single measure of belonging, alpha = .93 (intake ) .94 & exam).

4) *Goal affordances*. Participants indicated their intended future career and then rated the relevance of the course to their future career using a 7 point scale with endpoints “not at all” and “a great deal” and midpoint “somewhat”. They then rated whether their intended career would serve communal goals (e.g. “How much will your future career include helping other people directly?” “...include working closely with others?”; 4 items, alpha = .62 and whether it would serve agentic goals (e.g. “How much will your future career include achieving status or recognition?”; 3 items, alpha = .60; see [33]).

C. *Procedure*

1) *Intake survey*. Participants clicked on a link in the invitation email to access the survey. Participants first provided informed consent for the surveys and a FERPA release allowing access to their course grade and other educational information. Next, they provided demographic information including their age, racial and ethnic identity, and gender. They were asked to indicate the highest level of educational attainment for two parents or legal guardians; they were instructed to skip the questions for the second parent if they had only one parent, and to answer for the two parents with the highest educational attainment if they had more than two parents. The options provided were: “Some high school”; “High School”; “Some college”; “Associate’s or other 2-year degree”; Bachelor’s degree”; “Master’s degree”; “Doctoral degree (JD, MD, PhD, etc.)”; and “Unknown/Not Applicable/ Do not wish to disclose”. Participants were asked to indicate their family’s annual income using the response options “Less than $25,000”;

---

[2] Students must earn a C or higher in some of these courses in order for them to count toward certain engineering majors.

“$25,000-$50,000”; “$50,000-$100,000”; “$100,000-$150,000”;”$150,000-$200,000”; “Over $200,000”; and “Unknown/Do not wish to disclose”.

Participants then indicated their current year in school, whether they were currently a major in the College of Engineering and Computing, intended to declare a major in engineering/computing, or were/intended to major in another university division. They indicated their SAT/ACT score and high school GPA, and their high school coursework relevant to the course. For computer science, students indicated whether they had no computer science, introductory computer science, or advanced/PA computer science and if they had taken the AP Computer Science A or Computer Science Principles and/or IB Computer Science exams and their score(s). For Physics, …. Students in both courses indicated their highest level of high school mathematics (algebra; geometry; trigonometry/pre-calculus; calculus; advanced calculus or higher) and whether they had taken an AP examination in Calculus and/or an IB exam in Mathematics and their score(s).

Participants then completed the measures of efficacy, mindset, belongingness, and goal affordances described above.

2) *Post-exam survey*. Participants who had completed the intake survey received an email invitation to take the follow-up survey using a link provided in the email. Participants indicated whether their exam had been returned; students who indicated that the exam had not been returned were instructed to wait to take the survey until after it had been returned. Participants provided their exam grade as a numerical percentage (0-100). Next, they completed the ratings of efficacy, mindset, and belonging described in the materials.

*3) Follow up surveys.* Approximately 1 month after the post-exam survey, and again during the final two weeks of the semester, all participants who completed the post-exam survey were emailed an invitation email with a link to a follow up survey. Participants were shown a list of 19 different behaviors (e.g., “Read the textbook”; “Done practice problems”; “Posted a question to the course website discussion forum”) and asked to indicate how often they had engaged in each behavior in the past 2 weeks.

*4) Instructor data*. After the grade submission system had closed for the semester, instructors were contacted with a list of participants and asked to provide the final letter grade in the course for each student. In order to allow quantitative analyses, letter grades were converted into their corresponding GPA value on a 4 point scale.

## III. Results

Student survey responses were used to compare first-generation students, defined as students who had no parents or guardians who had completed a bachelor’s degree or higher, and low income students, here defined as those who indicated the had an annual family income of $50,000 or less, here called low income students, to other students. Their readiness for their engineering major, their beliefs, and their behaviors in the course are compared here.

### A. *Readiness*

*1) ACT score and Grade Point Average.* Students were asked about their ACT scores and their high school grade point average (GPA) on their intake survey (see Appendix A). Independent samples t-tests for equality of means were used to analyze their responses.

First generation students reported a mean ACT score of 29.17 (s.d. = 3.25), which did not differ from the mean score of their peers (M = 29.83, s.d. = 3.13), $t(189) = 1.04$, $p = .30$. Low income students reported significantly lower mean ACT score of 28.44 (standard deviation 3.33) than their peers mean ACT score of 29.90 (standard deviation 3.17), t(166) = 2.09, p = .04.

The high school GPA of first generation college students (M = 3.76 on a 4.0 scale, standard deviation 0.34), did not significantly differ from other students (M = 3.77 (standard deviation 0.36), t(189) = 0.16, p = .87. Likewise, the high school GPA of low income students (M = 3.76 (standard deviation 0.34), did not significantly differ from their peers (M = 3.75 (standard deviation 0.37), t(196) = 0.19, p = 0.85].

2) *High school mathematics and physics.* Students indicated their highest level of mathematics and physics studied in high school, as well as whether they had taken Advanced Placement (AP) or International Baccalaureate (IB) exams in those subjects, on their intake survey (see Appendix A).

Chi-square tests showed no significant difference in the high school math taken by first generation ($\chi^2(4) = 6.61$, p = .16) or low income ($\chi^2(4) = 2.10$, p = .72) students compared to their peers. Likewise, there were no differences in whether first generation ($\chi^2(1) = .04$, p = .85) or low income ($\chi^2(1) = 0.92$, p = .33) students had taken the AP or IB examination in mathematics.

There was no difference in the highest level of physics studied in high school between first generation college students and their peers ($\chi^2(2) = 1.73$, p = .42). Low income students were significantly more likely to have taken advanced or AP physics in high school than their peers (64% vs. 38%, $\chi^2(2) = 6.66$, p = .04). There was no difference in whether first generation ($\chi^2(1) = 0.82$ p = .37) or low income ($\chi^2(1) = 1.40$, p = .24) students had taken an AP or IB examination in physics relative to their peers.

B. *Beliefs*

1) *Efficacy.* Students were asked about efficacy on the intake survey and the post-exam survey (see Appendix B). Independent samples t-tests revealed no difference in beliefs about efficacy between first generation college students and their peers on the intake survey [t(230) = 0.64, p = .52] or on the post-exam survey [t(174) = -0.26, p = .80]. Similarly, there was no difference in beliefs about efficacy between low income students and their peers on the intake survey [t(201) = 0.22, p = .83] or on the post-exam survey [t(155) = 0.59, p = .56.]

2) *Mindset.* Students were asked about mindset on the intake survey and the post-exam survey (see Appendix C). Independent samples t-tests for equality of means indicated that first generation college students did not have different beliefs about intelligence than their peers did on the intake survey [t(24) = 0.75, p = .46] or the post-exam survey [t(174) = 1.05, p = .30]. Similarly, low income students did not have a different mindset than their peers on the intake survey [t(196) = 0.31, p = .76] or the post-exam survey [t(155) = 0.31, p = .76].

3) *Belonging.* Students were asked about belonging on the intake survey and the post-exam survey (see Appendix D). Independent samples t-tests for equality of means were used to analyze their responses. First generation college students were not different from their peers on this measure on the intake survey [t(132) = -1.56, p = .12] or the post-exam survey [t(86) = 0.54, p = .59]. Similarly, low income students were the same as their peers on this measure on the intake survey [t(104) = 0.36, p = .72] or the post-exam survey [t(68) = 0.34, p = .74].

*4) Goal Affordances.* Students were asked about the relevance of the course to their planned career, as well as their communal and agentic goals (see Appendix E). Independent samples t-tests for equality of means revealed no differences in the relevance of the course for either first generation college students [t(229) = 0.78, p = .44] or low income students [t(200) = 0.19, p = .85] compared to their peers. They also were similar  to their peers in their communal goals for their careers [first generation: t(229) = 0.58, p = .56; low income: t(200) = 0.46, p = .64]. Finally, there was no difference among students in their agentic goals for their careers [first generation: t(229) = 0.48, p = .63; low income: t(200) = 0.43, p = .67.]

*D. Achievement*

*1) Score on the First Exam.* On their post-exam surveys, students were asked to report their score on their first exam in their course, as a percentage score on a scale of 0 to 100. Neither first-generation [t(176) = 0.53, p = .60] nor low-income [t(157) = 1.4, p = .18] differed significantly from their peers' performance on the exam.

*2) Course Grade.* After the end of the semester, course instructors reported the letter grade participants had earned in the course (represented as a value on a 4-point scale, such that an A = 4 and F = 0.) Neither first-generation [t(214) = 1.03, p = .30] nor low-income [t(187) = 0.02, p = .98] students differed from their peers' final course grades.

*E. Behaviors*

On their follow up survey, students were given a list of different strategies for success that students adopt to be successful in their courses and asked how often they had engaged in these behaviors over the last two weeks (see Appendix F), where 1 indicated they had not engaged in the behavior at all in the past 2 weeks and 7 that they had done it on more than 5 different days in the previous 2 weeks. Independent samples t-tests for equality of means found first generation students were less likely than their peers to report having posted a question to an online discussion site or forum at the first follow-up, approximately one month after the exam, (Ms (s.d.) =  1.09 (0.43) vs.1.46 (1.21), t(94.23) = 2.57, p = .01). Low income students were also significantly less likely to have posted a question to an online discussion site or forum [Ms (s.d.) = 1.05 (0.22) vs. 1.50 (1.28), t(120.57) = 3.28, p = .001].  Additionally, relative to their peers, low income students reported that they had taken notes significantly less often during class [Ms( s.d.) = 3.50 (2.37) vs. 5.09 (2.36), t(121) = 2.75, p = .007] and had a study group with their peers marginally less frequently [Ms (s.d.) = 2.15 (1.60) vs. 2.93 (2.14), t(33.84) = 1.88, p = .07]. No other behaviors differed for either group, all t < 1.60, p > .11.

At the second follow up in the last two weeks of class, first generation students reported having read something other than the textbook or handouts significantly more often than their peers [Ms (s.d.) = 4.14 (2.29) vs. 2.86 (1.95), t(126) = 3.05, p = .003] and to have asked a question during class marginally more often [Ms = 3.24 (2.23) vs. 2.40 (1.79), t(126) = 1.88, p = .06]. No other behaviors differed for first generation students relative to their peers, all t < 1.60, p > .12. Low income students did not differ from their peers for any behavior at the second time point, t < 1.50, p > .15.

## III. Conclusion

There were very few differences between either first generation college students or low income students and their peers in this study. Despite other research showing lack of academic preparation in these populations [1], the first generation and low income students were nearly as ready for an engineering major as their peers were, judging by their high school background and performance. In fact, the first generation students had taken higher mathematics courses than their peers, though interestingly they were actually less likely to have taken the AP or IB exams in calculus. The low income students did have a lower ACT score than their peers did.

The beliefs of the first generation college students and low income college students in our study were not different from those of their peers. This contrasts sharply with past studies, which suggested that these students would have lower efficacy efficacy [5], more fixed mindsets [6], and a lower feeling of belonging[7] than other students. Additionally, low income students can be expected to have more communal goal affordances than others [29]; the low income and first generation students in our study had no difference from their peers in any of their goal affordances.

It is not surprising, then, that the first generation and low income students in this study achieved equivalent scores on their first exam in their course. Their behaviors in the course were also very similar, with differences on two of nineteen measures for first generation students and one of nineteen for low income students. We should note that these behaviors, as well as student beliefs about efficacy, mindset, belonging, and goal affordances, were self-reported, as were student grades on their first exam. The final grades in the course were reported by their instructors.

It is also worth noting the institutional context. The university at which the participants study makes an effort to support its first-year students. There is a three-day pre-college program that students of color and low-income students are especially encouraged to attend (though it is open to all) that introduces students to mentors and campus resources, there is a residential campus with a living-learning community program, there is a "University 101" class that all students take that acclimates them to university life and study, and there is a robust tutoring center which is free of charge. One possible explanation for the lack of differences between groups in the current research may be the efficacy of these programs in alleviating gaps found in previous research. However, since this research was not designed to test the efficacy of any or all of these programs, such an explanation is clearly speculative. In any case, the effects of these programs might be short term. Once students get further into their college career and their engineering major, they will be farther away from any pre-college workshop and from their "University 101" class, and they will be much less likely to be in a living-learning community and more likely to be living off campus. A longitudinal study could address this issue, following students through their programs and tracking any changes in student beliefs, behaviors, and achievement.

## References


[1] G. R. Pike and G.D. Kuh, G.D., "First- and second-generation college students: A comparison of their engagement and intellectual development," *J. of Higher Educ.,* vol. 76, no 3, pp. 276-300, May/Jun., 2005.

[2] D. MacPhee, S. Farro, and S.S. Canetto, "Academic self-efficacy and performance of underrepresented STEM majors: Gender, ethnic, and social class patterns," *Analyses of Social Issues and Public Policy,* vol. 13, no. 1, pp. 347–369, Dec., 2013.

[3] L. Camera (2017, May 25). Low-income students nowhere to be found in STEM. *U.S. News and World Report.* Available: https://www.usnews.com/news/stem-

solutions/articles/2017-05-25/low-income-students-nowhere-to-be-found-in-stem, May 25, 2017.

[4] J. M. Allen, G.A. Muragishi, J.L. Smith, D.B. Thoman, and E.R. Brown, “To grab and to hold: Cultivating communal goals to overcome cultural and structural barriers in first-generation college students’ science interest,” *Translational Issues in Psychological Sci.,* vol. 1, no. 4, pp. 331-341, Dec., 2015.

[5] J. Han, Han, X. Chu, H. Song, and Y. Li, “Social capital, socioeconomic status, and self-efficacy,” *Appl. Econ. and Finance*, vol. 2, no. 1, Feb., 2015.

[6] S. Claro, D. Paunesku, and C.S. Dweck, “Growth mindset tempers the effects of poverty on academic achievement,” *PNAS*, vol. 113, no. 31, pp. 8664-8668, Aug. 2, 2016.

[7] J.M. Ostrove and S.M. Long, “Social class and belonging: Implications for college adjustment,” *The Review of Higher Educ.*, vol. 30., no. 4, pp. 363-389, Jun., 2007.

[8] V.B. Saenz, S. Hurtado, D. Barrera, D. Wolf, and F. Yeung, “First in my family: A profile of first-generation college students at four-year institutions since 1971,” The Foundation for Independent Higher Education, 2007.

[9] P. Hsieh, J.R. Sullivan, and N.S. Guerra, “A closer look at college students: Self-efficacy and goal orientation,” *J. of Advanced Academics*, vol. 18, no. 3, pp. 454–476, Spring 2007.

[10] A. Bandura, “Social cognitive theory: An agentic perspective,” *Asian J. of Social Psychology*, vol. 2, no. 1, pp. 21–41, Apr., 1999.

[11] G.D. Markman, D.B. Balkin, and R.A. Baron, “Inventors and new venture formation: The effects of general self-efficacy and regretful thinking,” *Entrepreneurship Theory and Practice,* vol. 27, no. 2, pp. 149-165, Winter 2002.

[12] J. Lane and A. Lane, “Self-efficacy and academic performance,” *Social Behavior and Personality: An Int. J.* vol. 29, no. 7, pp. 687-694, 2001.

[13] C.S. Dweck and E.L. Leggett, “A social-cognitive approach to motivation and personality,” *Psychological Review*, vol. 95, no. 2, pp. 256-273, Apr., 1988.

[14] J. Boaler, “Ability and mathematics: the mindset revolution that is reshaping education,” *Forum*, vol. 55, no. 1, pp. 143-152, 2013.

[15] H. Grant and C.S. Dweck, “Clarifying achievement goals and their impact.” *J. of Personality and Social Psychology*, vol. 85, no. 3, pp, 541-553, Sep., 2003.

[16] M.W. Kraus, P.K. Piff, R. Mendoza-Denton, M.L. Rheinschmidt, and D. Keltner, “Social class, solipsism, and contextualism: How the rich are different from the poor,” *Psychological Review*, vol. 119, no. 3, pp. 546-572, Jun., 2012.

[17] R.F. Baumeister and M.R. Leary, “The need to belong: Desire for interpersonal attachment as a fundamental human motivation,” *Psychological Bulletin*, vol. 117, no. 3, pp. 497–529, May, 1995.

[18] S.D. McMahon and J. Wernsman, “The relation of classroom environment and school belonging to academic self-efficacy among urban fourth- and fifth-grade students,” *The Elementary School J.*, vol. 109, no. 3, pp. 267-281, Jan., 2009.

[19] S.G. Brainard and L. Carlin, “A six-year longitudinal study of undergraduate women in engineering and science,” *J. of Engineering Educ.*, pp. 369-375, Oct., 1998.

[20] L.R.M. Hausmann, J.W. Schofield, and R.L. Woods, “Sense of belonging as a predictor of intentions to persist among African American and White first-year college students,” *Research in Higher Educ.*, vol. 48, no. 7, pp. 803-839, Nov., 2007.

[21] N.M. Stephens, T.N. Brannon, H.R. Markus, and J.E. Nelson, “Feeling at home in college: Fortifying school-relevant selves to reduce social class disparities in higher education,” *Social Issues and Policy Review*, vol. 9, no. 1, pp. 1-24, Jan., 2015.

[22] J.M. Ostrove, “Belonging and wanting: Meanings of social class background for women's constructions of their college experiences,” *J. of Social Issues*, vol. 59, no. 4, pp. *59*. 771–784, Dec., 2003.

[23] M. Gibbons, “College-going beliefs of prospective first-generation college students: Perceived barriers, social supports, self-efficacy, and outcome expectations,” Ph.D. Thesis, Counseling and Educational Development, UNC Greensboro, Greensboro, NC, 2005.

[24] J.M. Billson and M.B. Terry, “In Search of the Silken-Purse: Factors in Attrition among First-Generation Students,” Annual Meeting of the Association of American Colleges, Denver, 1982.

[25] M. Jury, A. Smeding, N.M. Stephens, J.E. Nelson, C. Aelenei, and C, Darnon, “The experience of low-SES students in higher education: Psychological barriers to success and interventions to reduce social-class inequality,” *J. of Social Issues*, vol. 73, no. 1, pp. 16-34, Mar., 2017.

[26] J. Aronson, C.B. Fried, C.B., and C. Good, “Reducing the effects of stereotype threat on African American college students by shaping theories of intelligence,” *J. of Experimental Social Psychology*, vol.38, no. 2, pp. 113-125, Mar., 2002.

[27] A.B. Diekman and M. Steinberg, “Navigating social roles in pursuit of important goals: A communal goal congruity account of STEM pursuits,” *Social and Personality Psychology Compass*, vol. 7, no. 7, pp. 487–501, Jul., 2013.

[28] A.B. Diekman, E.K. Clark, A.M. Johnston, E.R. Brown, and M. Steinberg, “Malleability in communal goals and beliefs influences attraction to stem careers: Evidence for a goal congruity perspective,” *J. of Personality and Social Psychology*, vol. 101, no. 5, pp. 902-918, Nov., 2011.

[29] N.M. Stephens, A.G. Dittmann, and S.S.M. Townsend, “Social class and models of competence: How gateway institutions disadvantage working□class americans and how to intervene,” In *Handbook of competence and motivation*, *2nd Edition: Theory and application.*, New York, Guilford Press, pp. 512-528, 2016.

[30] C.S. Dweck, *Self-theories: Their Role i Motivation, Personality, and Development.* Ann Arbor, Psychology Press, 1999.

[31] G.M. Walton and G.L. Cohen, “A question of belonging: Race, social fit, and achievement,” *J. of Personality and Social Psychology,* vol. 92, no. 1, pp. 82–96. Jan., 2007.

[32] C. Goodenow, “The psychological sense of school membership among adolescents: Scale development and educational correlates,” *Psychology in the Schools*, vol.30, pp. 79-90, Jan., 1993.

[33] A.B. Diekman, E.R. Brown, A.M. Johnston, and E.K. Clark, “Seeking congruity between goals and roles: A new look at why women opt out of science, technology, engineering,

and mathematics careers,” *Psychological Science*, vol. 21, no. 8, pp. 1051-1057, Aug., 2010.

## Appendixes

### Appendix A: Demographic Survey

We would like to get more information about you in order to ensure that different groups of people are fairly represented in our research. You may skip any question you do not wish to answer.

Please enter your age.

I am: (choose all that apply)

- White
- Black or African American
- American Indian or Alaska Native
- Asian
- Native Hawaiian or other Pacific Islander
- Other (please specify)
- Do not wish to disclose

I am:

- Hispanic
- Non-Hispanic
- Do not wish to disclose

I am:

- Male
- Female
- Other/ Do not wish to disclose

The next two questions refer to your parents' or legal guardians' educational background. If you have only one parent or legal guardian, please skip the second question or indicate "not applicable". If you have more than two parents or legal guardians, please choose the parents/legal guardians with the highest level of educational attainment.

What is the highest level of education attained by your parent or legal guardian with the highest level of educational attainment?

- Some high school
- High school
- Some college
- Associate's or other 2-year degree
- Bachelor's Degree

- Master's Degree
- Doctoral Degree (JD, MD, PhD, etc.)
- Unknown/ Not Applicable/ Do not wish to disclose

What is the highest level of education attained by your parent or legal guardian with the second-highest level of educational attainment?
- Some high school
- High school
- Some college
- Associate's or other 2-year degree
- Bachelor's Degree
- Master's Degree
- Doctoral Degree (JD, MD, PhD, etc.)
- Unknown/ Not Applicable/ Do not wish to disclose

What is your family's annual income?
- Less than $25,000
- $25,000-50,000
- $50,000-100,000
- $100,000-$150,000
- $150,000-$200,000
- Over $200,000
- Unknown/Do not wish to disclose

We'd like to learn more about you as a student. You may skip any question you do not wish to answer.

Are you a major in the College of Engineering and Computing? (If you are a University Studies student, indicate the division in which you most likely intend to eventually major)
- Yes, I am an engineering/computing major
- No, I have another major

What was your ACT (or SAT) score?

GPA What was your high school GPA on a 4-point scale?

AP What was the highest level of physics you studied in High School?
- Did not take a physics course
- Introductory physics
- Advanced or AP Physics

AP Which of the following AP examinations did you take, if any?
- AP Physics 1
- AP Physics 2

- AP Physics C: Mechanics
- AP Physics C: Electricity and Magnetism

Did you take the International Baccalaureate (IB) examination in Physics?
- Yes
- No

What was the highest level of mathematics you studied in High School?
- Algebra
- Geometry
- Trigonometry/ pre-calculus
- Calculus
- Advanced calculus or higher

Did you take the AP examination in Calculus?
- No
- Yes, Calculus AB
- Yes, Calculus BC

Did you take the International Baccalaureate (IB) examination in Mathematics?
- Yes
- No

## 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: 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 D: Belongingness

We are interested in your perception of the people in the Department of [Computer Science and Software Engineering/ Physics].  Please indicate how well the following questions describe how you feel about the students, faculty, and staff in the Department of [Computer Science and Software Engineering/ Physics] right now.

- People in the Department of [Computer Science and Software Engineering/ Physics] like me.
- I feel like I belong in the Department of [Computer Science and Software Engineering/ Physics].
- I fit in well in the Department of [Computer Science and Software Engineering/ Physics].
- I feel comfortable in the Department of [Computer Science and Software Engineering/ Physics].
- People in the Department of [Computer Science and Software Engineering/ Physics] are a lot like me.
- I feel like a real part of the Department of [Computer Science and Software Engineering/ Physics].
- People in the Department of [Computer Science and Software Engineering/ Physics] notice when I'm good at something.
- It is hard for people like me to be accepted in the Department of [Computer Science and Software Engineering/ Physics].
- Other students in the Department of [Computer Science and Software Engineering/ Physics] take my opinions seriously.
- Sometimes I feel as if I don't belong in the Department of [Computer Science and Software Engineering/ Physics].
- People in the Department of [Computer Science and Software Engineering/ Physics] are friendly to me.
- I am included in a lot of activities in the Department of [Computer Science and Software Engineering/ Physics].
- I am treated with as much respect as other students in the Department of [Computer Science and Software Engineering/ Physics].
- I feel very different from most other students in the Department of [Computer Science and Software Engineering/ Physics].

- I can really be myself in the Department of [Computer Science and Software Engineering/ Physics].
- People in the Department of [Computer Science and Software Engineering/ Physics] know I can do good work.
- I feel proud of belonging to the Department of [Computer Science and Software Engineering/ Physics].
- Other students in the Department of [Computer Science and Software Engineering/ Physics] like me the way I am.

## Appendix E: Goal Affordances

For the following questions, please consider your most likely future career. We know that you might be uncertain about your future career or what it will be like; for now, please just give your best guess about that career. (Each item had a 7 point scale with endpoints “not at all” and “a great deal” and midpoint “somewhat”.)

Relevance (note that these labels did not appear in the survey)

- How relevant is this course to your future career?

Communal Goals (note that these labels did not appear in the survey)

- How much will your future career include helping other people directly?
- How much will your future career include working closely with others?
- How much will your future career include working within a national or global community?
- How much will your future career include benefitting society?

Agentic Goals (note that these labels did not appear in the survey)

- How much will your future career include achieving status or recognition?
- How much will your future career include financial rewards?
- How much will your future career include holding power?

## Appendix F: Student Behaviors

Different students adopt different strategies in their courses. Below is a list of things some students might or might not do in different courses. We are interested in the things you are and are not doing in your physics course. Please ONLY indicate the things you've done in your physics course, not any other courses you are taking.

Think back over the past 2 weeks. Have you done any of the following things in PHY 191 during the past 2 weeks? Please give your best estimate of how many times you've done each of these things. (Each item had a 7-point scale, with the points “Haven’t done”, “1 day”, to “More than 5 days”.)

- Read the textbook

- Reviewed slides or handouts from class
- Reviewed your own notes from class
- Attended class
- Met with the professor outside class (e.g. office hours)
- Met with the TA outside class (e.g. office hours)
- Gone to a tutoring session for this course
- Asked a question during class
- Gone to a general study skills workshop
- Had a study group with classmates
- Done the homework for class
- Done additional practice problems
- Taken notes during class
- Taken notes while reading the textbook
- Gone to the writing center for help with an assignment in this course
- Read something other than the textbook or handouts from class (e.g., a study guide, a different textbook, etc.)
- Posted a question to an online discussion board
- Answered a question in class
- Re-read sections of the textbook to review material