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Entrepreneurial-minded learning modules reveal differential learning characteristics in historically marginalized groups

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ABSTRACT

The entrepreneurial-minded learning (EML) strategy has been of recent interest in collegiate-level courses to encourage an application-focused framework of thought. EML approaches to coursework involve the development of assignments or projects that lead students to actively think and participate in designing and justifying the practical application of products. For biomedical engineering (BMEG) students, this approach has value due to the high degree of importance that design in healthcare and commercial BME-related ventures entails. We created an EML project in a sophomore-level biomechanics course that aimed to develop entrepreneurial skills through designing an orthopedic implant using biomechanical concepts. We have previously demonstrated that this approach increased the ability to create connections between coursework and real-world applications, the ability to communicate the value that the coursework provides, and their curiosity regarding unanswered questions in the field. While these results were encouraging, entrepreneurship and engineering, in general, is a particularly discrimination-rich landscape due to a historic bias for White and Asian men. Historically marginalized minorities (HRMs), including women and first-generation college students, are underserved in upper-level education systems. Consequently, it is necessary to investigate the impact of the coursework on HRM groups to generate curricula that encourage and maintain diversity in engineering.

We distributed an EML project containing three sections that: (1) asks students to write a paper on a treatment plan including an orthopedic implant for a provided patient profile, (2) create a presentation presenting this plan to the stakeholders, and (3) determine the biomechanical properties that the implant and any selected materials need to satisfy. Using a pre- and post-project survey from two cohorts of students, we determined the effectiveness of the assignment and gauged the extent to which students believed that their demographics influenced their motivation. Demographic-based influences are defined here as whether students believe that they are more motivated to be successful in their major based on their race, gender, community, etc. Our data demonstrate that EML scores, which is a scale we designed to quantify the successful development of target EML skills, had no consistent pattern based on race, but that female students reported a significantly lower score compared to male students. We additionally developed a panel of questions gauging the extent to which certain groups of students were motivated by their demographics (e.g., gender, race, etc.) and individual economic benefits of BMEG (e.g., high-paying jobs, career preparation, etc.). Female students were also more likely to report that they were motivated by their demographics and had significantly lower self-efficacy scores compared to male students. While race had no impact on the final EML score, HRM groups were more motivated by their demographics and were equally motivated compared to non-marginalized races by economic benefits. To gain further resolution on failure points of the EML project, we mined short-answer responses using sentiment analysis methods and report differential patterns depending on the demographic.

These data demonstrate low confidence and lower overall EML scores in female students in addition to an increased motivation to pursue BMEG driven by social aspects rather than economic outcomes. The latter result is shared by HRM groups, but the average EML score within this group is consistent with that of the non-marginalized group. These data will serve as a roadmap to develop coursework that serves all students.

1. Introduction

Entrepreneurial-minded learning (EML) has emerged as a relatively popular pedagogical approach due to the increasing emphasis of industry applications in engineering education. Particularly in the case of biomedical engineering (BME), with the increase of biotech companies, a growing majority of BME undergraduate students are entering biotech industries post-graduation [1], [2], [3]. National interest through initiatives such as the Kern Entrepreneurial Engineering Network (KEEN) have galvanized the increase of curriculum content geared to promoting entrepreneurship [4]. Concomitantly, interest in incorporating more course material geared towards industry applications has resulted in the design and delivery of projects permitting students to develop and practice entrepreneurship in the classroom. EML-based project and module design has achieved many successes in improving critical thinking skills and developing entrepreneurial skills in undergraduate courses [5], [6], [7]. While a net positive response is generated from students, distinguishing outstandingly successful programs from those that provide minor benefits remains difficult [8]. An additional issue for EML design is preconceived notions of entrepreneurship leading to defeatist or indifferent mindsets. Representation among entrepreneurs is heavily biased toward White or Asian males, indicating a concerning lack of reach. Further, there is a common misconception that entrepreneurship is primarily a function of an individual's personality rather than a set of skills and training that can yield entrepreneurial success [8]. Representation among entrepreneurs is heavily biased toward White or Asian males, indicating a concerning lack of reach [9], [10]. We aim to delineate the cause and consequences of this representational bias by distributing a project designed using the EML methodology to evaluate whether increasing the distribution of opportunities to think as an entrepreneur can positively influence student perceptions of entrepreneurship, thus improving the diversity of future entrepreneurs.

The concepts governing the EML framework are based on developing three distinct characteristics: curiosity, connections, creating value, and integrating design with opportunity recognition and impact evaluation (**Figure 1**). Although EML is a promising candidate for integrating entrepreneur and industry-oriented thinking into engineering education, rigorous design and careful distribution of the content is necessary to successfully instill EML outcomes [4], [11], [12]. EML modules have been developed across multiple engineering programs, most notably for BME due to a particularly dense curriculum requiring equal parts basic biology and engineering courses.

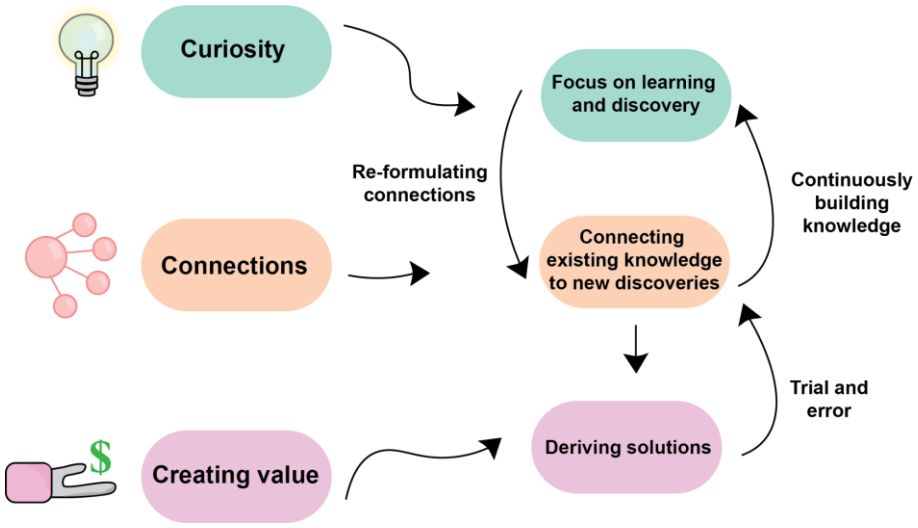

Figure 1: Flowchart illustrating entrepreneurial mindset (EML) strategy. Curiosity towards a subject motivates the discovery of connections between problem solving and building knowledge. Societal value can be created using this feedback loop and motivate additional improvements of design opportunities.

We previously developed an EML project that simulates real interactions with customers and patients for a sophomore-level biomechanical engineering course [13]. The project involved three distinct modules that serves as a tutorial for the three steps of engineering design: (1) identifying a problem, (2) evaluating available solutions and potential improvements, and (3) pitching the product to the patient and stakeholders. To encourage students to think critically, we specifically requested that students provide a more experimental solution to the problem and generate a plan to mitigate potential failures. In the spirit of EML creative thinking, we also intentionally retained a vague project description and instructions. The students would produce two papers and a short presentation in the style of a pitch meeting in addition to survey evaluations both prior to project delivery and as an endpoint. The project timeline spanned the entire semester of the course and was performed in groups of three to four students randomly assigned. As Likert scale responses often fail to grasp the complex student response to the project, we used text analysis software to determine the overall themes present in open response feedback questions. We were able to validate an overall increase in EML scores and report a lukewarm if not positive response to the project. The introduction of EML in the project significantly enhanced student self-evaluations for curiosity, connections, and value creation compared to a control group of students provided with the same project lacking EML components.

To analyze for correlations between demographics and responses to the EML assignment, we designed additional questions for to what degree students were more motivated by factors such as race, gender, etc. Using the data from the previous study and a replicate experimental group within a second cohort, we aim to ascertain whether differential responses to the project were conferred for historically marginalized minorities (HRMs). We distributed the EML assignment

to two student cohorts without a control group due to a small fraction of HRMs being present in each cohort, which is additionally concerning. Using the same analysis methods and more in-depth considerations of short response patterns, we demonstrate significant patterns and considerations for designing inclusive course content. These analyses are critical to ascertain the distribution of successful assignments and assess potential points of failure in the course content.

2. Methods

2a. Project Development

The EML project consists of three modules that allow students to select one of two patient cases requiring a hip or knee implant. The students are asked to develop a comprehensive treatment plan, present the treatment plan in a project pitch format, and use biomechanical engineering concepts learned in class to enhance the sophistication of their designs/evaluate problems that may arise due to the implant material or design selected. The project deviates from the previous studies in that only the EML-centered project is used and survey questions specifically determine the relationship between demographics and responses. The overall aim of the project was to step-by-step allow students to go through the process of designing, pitching, and evaluating or re-designing their approach for biomedical problem-solving.

Two patient profiles were assigned with different injuries and personal considerations such as tomophobia and metal allergies. The full project assignment is provided in the supplement. The treatment plan assignment deliverable was a paper reviewing the current implant design state of the art and justifying a single design in the context of the selected patient. Students were evaluated on the depth of their content knowledge and how convincing their treatment plan was given the available options. This treatment plan includes surgical approaches to inserting the implant, suggested materials and geometry, and identification of experimental approaches that may suit the patient. While surveying existing commercially available options was suggested, students were not solely restricted to implants already on the market. Students were also asked to include a section connecting their treatment plan to biomechanical engineering concepts and how real-world issues such as insurance plans and financial feasibility. A page length minimum and maximum was not provided to allow students the freedom to determine the requisite depth of their report. While a rigorous rubric was used for grading - a curve was supplied to thoroughly evaluate performance without significantly impacting grades.

The second module builds off the first module developing a PowerPoint presentation pitch using the treatment plan designed in the first assignment. Students were asked to generate a sales pitch no longer than 7 minutes that effectively convinced the audience that the selected treatment plan was effective and optimal for their patient. Visual aids and logical decision-making with the student's current state of knowledge must be demonstrated with good slide-making practices. This includes sufficient presentation practice and attractive slide designs.

The third module serves to consolidate the previous modules with the biomechanics principles culminating at the end of the semester. As a result, students must validate that the implant geometry and material are able to sustain forces incident on the implant using force diagrams and modeling the material stress and strain in multiple situations. We requested that students perform a literature review on the forces that are natively incident on the bone. Students were required to cite sources validating their assumptions and work through their solutions. Additionally, the students must suggest potential failure scenarios based on their knowledge or research on implant failure as revision surgeries are common in the orthopedic field. Using this scenario, the students must also develop a response to the public and a strategy to address the potential of this failure in the future.

2b. Survey distribution and design

The experiments performed in this study were conducted with a formal approval from the University of [] Institutional Review Board (IRB) to conduct the study under a normal academic environment. The survey design included the original questions from the proof-of-concept study and incorporated additional questions evaluating sources of motivation and self-efficacy using Likert-scale questions. Before completing the survey, students were able to anonymously submit their demographics including race, first-generation status, gender, and whether they identified as a member of the LGBTQIA community. The first block following demographics consisted of 7 questions evaluating the students' self-efficacy or their belief in their own abilities. Self-efficacy in this context was determined in terms of the ability to act as an engineer and entrepreneur or to solve problems intelligently and creatively. The second bock of 5 questions determined the underlying motivation of the student and whether their motivations were related to their own demographics. For instance, whether a student feels that nationality or gender group is integral to their motivation to pursue biomedical engineering. The third block of 4 questions focused on determining why students selected the BME major: e.g. whether the interest in BME is related to the economic benefits or a particular enjoyment of BME concepts. The next few sections of questions evaluate a student's development of curiosity, connections, and value creation as previously described. The final section of open-ended questions asked students to evaluate the effectiveness of the project and whether there were suggestions as to how we could improve the project design. Responses were analyzed downstream in the context of demographics including gender identity, race, and first-generation status.

2c. Statistical analyses

Statistical analyses were performed using parametric tests due to the normal distribution of Likert-like data with the higher numbers of participants [7]. However, for groups separated based on demographics, there were some n = 1 analyses that cannot reliably be analyzed with any

statistical significance. Nonetheless, it may still be possible to derive some hypotheses despite the low number of participants that fall within some of the HRM groups. It is important to note this lack of population-based conclusions in certain subsections of the data, which is emphasized in the aforementioned results. Sentiment analyses were performed in R using the tidyverse packages to gain a sense of whether short-response questions are composed of more positive or negatively correlated words. These analyses were performed using the open-source AFINN lexicon.

3. Results

3a. Demographics distributions and correlations with EML skills

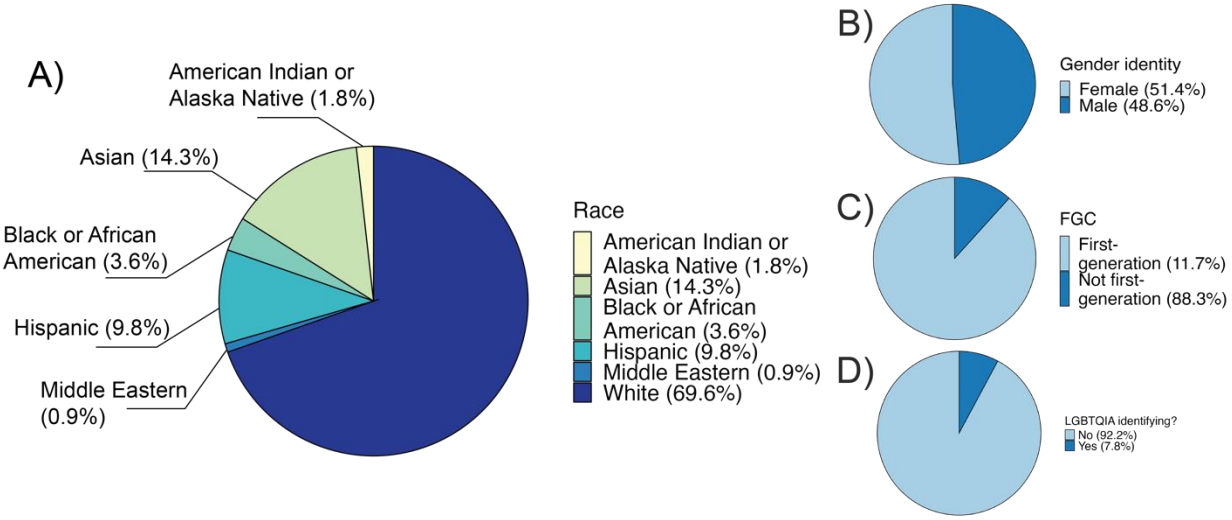

Figure 2: Demographics and overall EML scores. A) Low fractions of students from pooled data of two cohorts illustrate a lack of diversity in this course's composition. B) Even distribution of genders with no students indicating LGBTQIA membership, indicating a further lack of diversity or a discomfort in responding positively. C) Small fraction of students reported being first-generation compared to the bulk of the student cohorts. D) Low representation of LGBTQIA-identifying students only in the second cohort. Despite providing an open response to further clarify, students provided no additional information.

Less than 20% of each cohort contained minority groups underrepresented in the context of entrepreneurship while gender identity was nearly evenly split with only three students identifying as a member of the LGBTQIA community (**Figure 2**). A fraction of 11.7% of students reported being the first of their family to enter higher education (**Figure 2C**). The cohorts analyzed in this study was composed of 58 and 55 students, respectively, which unfortunately results in a low sample size for historically underrepresented minorities (HRMs). Consequently, many of these analyses cannot be reliably assessed for statistical significance. Further, the lack of diversity within the classroom is an additional concern that should be addressed by interrogating the accessibility of higher degrees to HRM students. A question determining whether students identified as

LGBTQIA was included in the second cohort, but a lack of additional information prohibits drawing any further conclusion combined with a low representation of <8% (**Figure 3D**).

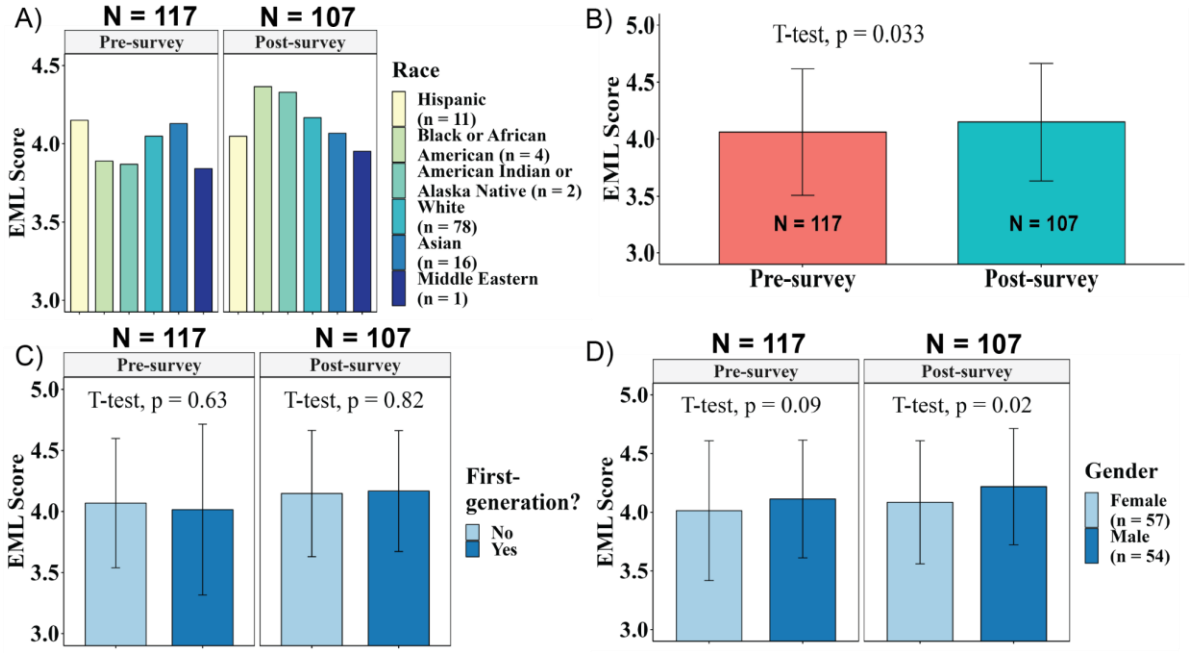

Figure 3: EML scores depending on demographics. A) EML scores based on race demonstrate no convincing pattern with respect to HRMs. B) EML scores increased significantly overall by a small margin in the pool of both cohorts. C) FGC students and non-FGC students demonstrate no difference in EML score both before and after assignment delivery. D) Female students on average reported a lower EML score compared to their male counterparts.

The preliminary data collected for initial analysis was limited by a lack of HRM-identifying students in the first cohort, therefore, statistical analyses were not performed on results based on race due to a high variance in sample sizes. On a qualitative level, students from a marginalized race responded with noticeably larger increases in average EML skill score between the pre-assignment and post-assignment survey compared to well-represented White and Asian students (**Figure 3A**). However, the final EML score of HRM students after assignment delivery was lower than that of well-represented students (**Figure 3A**). These data suggest that the EML project had a larger impact on increasing student self-assessment of EML skills for HRMs, but the final post-survey score was lower than both well-represented groups. The average increase of EML score in the pre- and post-surveys prove that the cohorts participating in this study demonstrate similar responses to the cohorts participating in the preliminary study (**Figure 3B**).

Similar patterns could not be derived from organizing with respect to first-generation status, suggesting that FGC students were indistinguishable from non-FGC in terms of the overall EML skill increase (**Figure 3C**). Based on these results, we believe further investigating the reason

behind these apparent disparities is necessary to develop solutions. To further examine the source of these disparities, we included questions gauging perceived efficacy and sources of motivation grouped as either socially or occupationally oriented in the initial survey using a Likert scale. Further, EML scores between different gender groups illustrated no statistical significance in the pre-assignment survey based on a student's T-test. However, in the post-survey, female students scored significantly lower compared to male students (**Figure 3D**). The post-assignment EML scores for female students were low both compared to male students before and after assignment completion and compared to the female pre-assignment scores. This result indicates that the EML project has a reduced effect on female student groups as a method of supplying confidence in EML skills.

3b. Low self-efficacy scores in female students

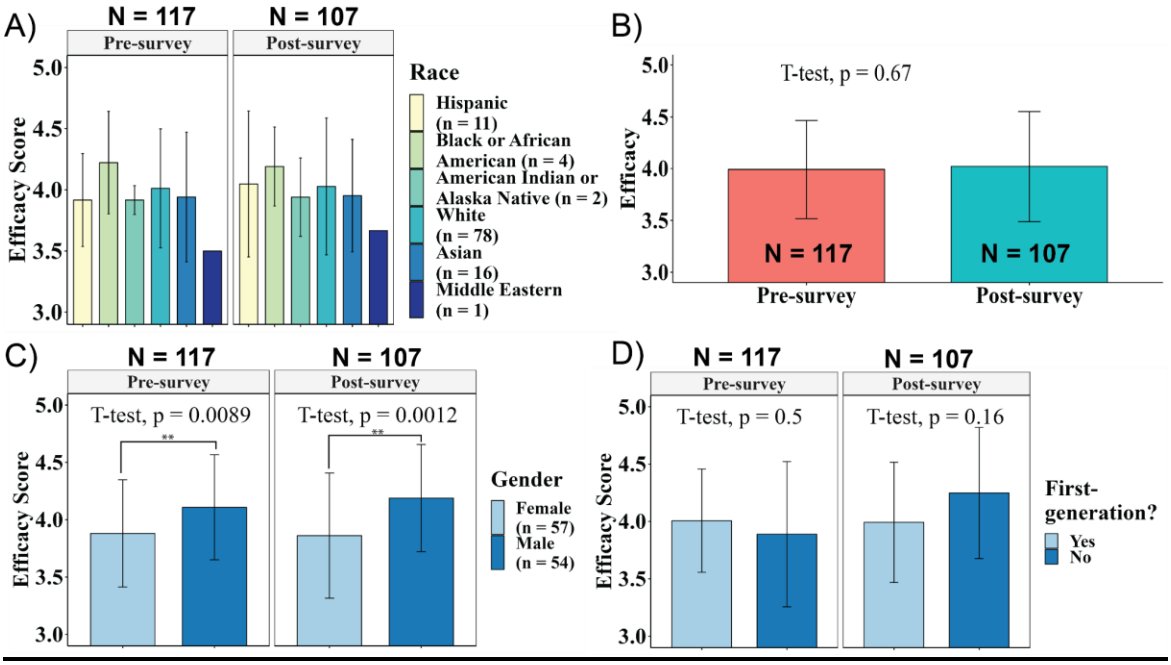

Figure 4: Self-efficacy scores reported by students before and after the project. A) Again, no clear relationship between efficacy and race group. B) Self-efficacy scores overall had no difference between the pre- and post-survey of both cohorts. C) Self-efficacies were significantly lower in female students compared to male students both before and after the project. D) No significant self-efficacy changes between FGC and non-FGC but self-efficacy increases in FGC students post-EML project were less effective compared to non-FGC students.

The self-efficacy scores as reported here indicate a student's confidence in their ability to accomplish tasks related to EML skills. We hypothesized that the patterns observed in the previous results may be explainable or elaborated on through questions about self-efficacy or motivation. Similar to the EML skill surveys, these questions were answered on a Likert-like scale of 1 - 5. Organizing scores with respect to race additionally demonstrates no clear correlation with, again,

very little change in the pre- and post-survey (**Figure 4A**). Self-efficacies in the entire pooled student cohorts indicate no significant change before and after the distribution of the project (**Figure 4B**). This pattern follows in FGC students with the exception of non-FGCs increasing in efficacy overall compared to FGCs, which retain no statistically different shifts (**Figure 4D**). However, in the groups separated based on gender, in both surveys, self-efficacy in female students is significantly lower compared to their male counterparts (**Figure 4C**). Many similar datasets assessing the confidence of female students demonstrate a similar trend of low self-efficacy, and low confidence, in female student populations [14]. Self-efficacy reported in the post-survey was, further, lower than the pre-survey for female students, indicating that a belief in individual academic success may have reduced after completing the project.

3c. Demographics influencing motivation sources for students

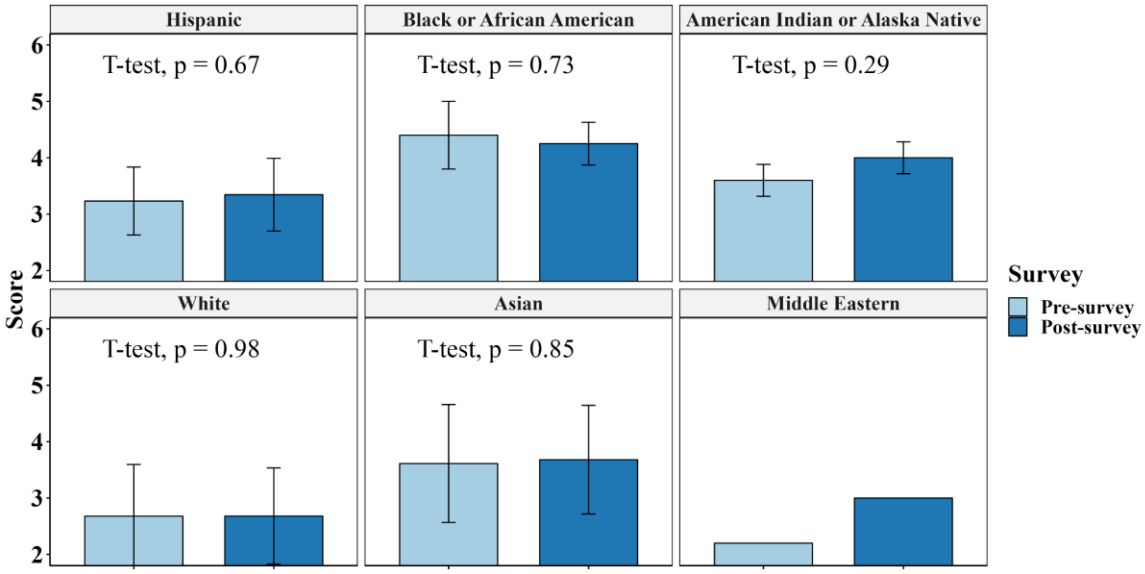

Figure 5: Likert-like rating of the degree to which social and demographical circumstances influence the motivation of students. No correlation was derived between the pre- and post-survey. However, HRMs were, on average, more motivated by social circumstances.

We next sought to determine whether certain groups were more or less differentially motivated by social factors that influence a feeling of belonging within their cohort or major as a whole. Social motivations varied significantly depending on race with little change between pre- and post-survey responses (**Figure 5**). African-American students responded that they, in particular, felt motivated by racial group, gender, student fellowship, etc. Most groups, excluding Middle Eastern due to the low sample size of one, responded with more social motivation compared to white students.

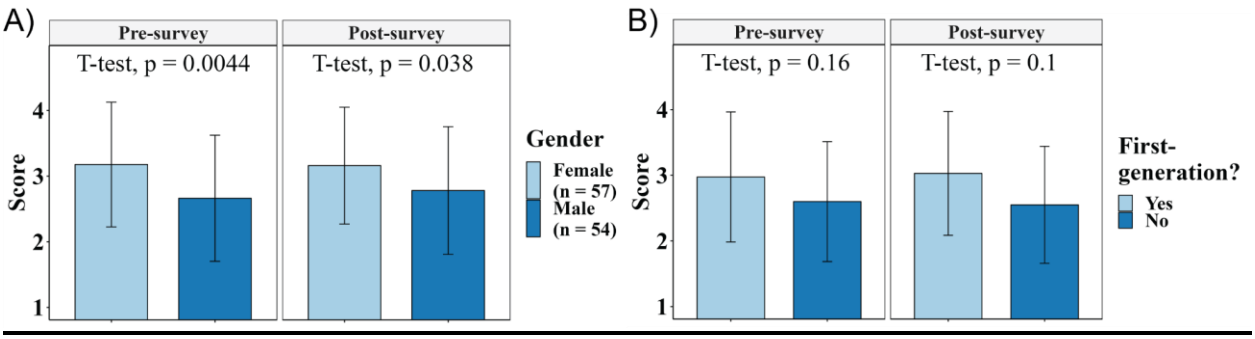

Figure 6: Likert-like rating of the degree to which social and demographical circumstances influence the motivation of students. A) Female students reported a statistically significantly higher motivation by social circumstances than male students. B) No significant relationship between FGC students and non-FGC students.

Partitioning the data based on gender demonstrated a statistically significant increase in social motivation in female compared to male students (**Figure 6A**). However, FGC students had no statistically significant relationship (**Figure 6B**). The most significant distinctions can be viewed through comparisons between female and male students, which is itself an interesting observation. However, it is also possible that a relatively equivalent sample size from each group may have influenced these outcomes. Occupational motivators including the high starting salary of biomedical engineers were incredibly consistent between different HMGs, indicating that HMG status has no impact on the degree to which occupational benefits motivated these biomedical engineering students (**Supplement Figure 1A&B**).

3d. Complex text analyses for student short responses

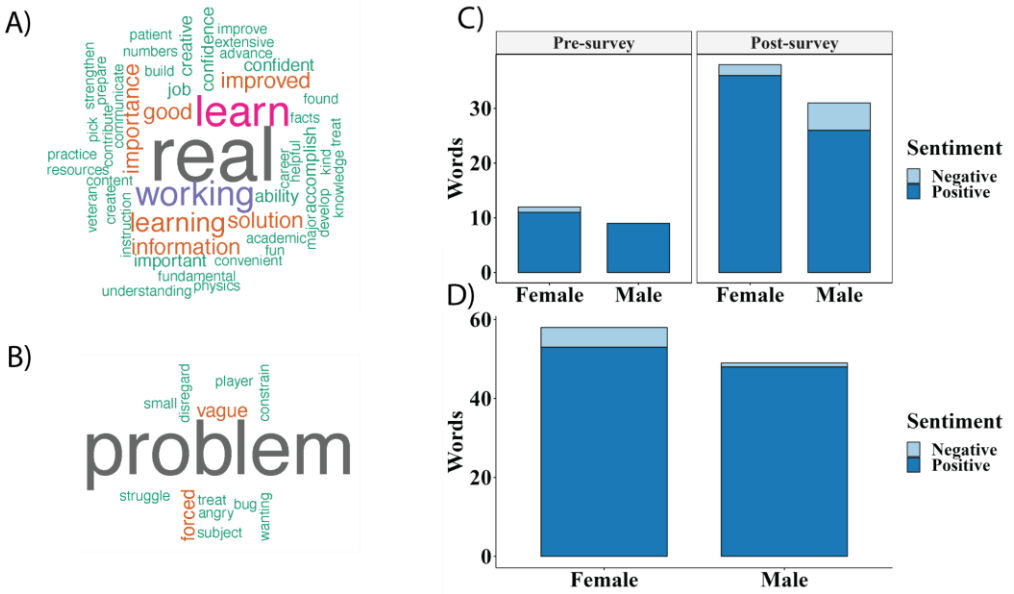

Figure 7: Sentiment analysis of short-response answers using the AFINN lexicon. A) Positively-connotated words are more abundant than B) negatively-connotated words for questions assessing

the project's impact, indicating an overall positive association. Among the various organizations of the dataset C) word density increased in post-surveys compared to pre-surveys with consistently more female students responding with words that contain either a positive or negative connotation. D) Female students responded with an increase in negative connotations to questions about confidence compared to male students.

Sentiment analyses were performed on the open response data from the pre- and post-surveys collected before and after the project. The data was separated based on questions with the most significant conclusions being detailed here. Unilaterally, words with positive connotations were significantly higher in density than those with negative connotations (**Figure 7A&B**). From the previous data, EML scores, self-efficacy, and social motivations are most significantly different between male and female students. Similarly, this trend follows for the sentiment analysis data. We provided a suggestion question to determine whether students were able to provide differential suggestions for the biomedical engineering program based on their experiences with the project. While female students used negative connotations in the pre-survey whereas male students did not, in the post-survey, male students expressed a higher ratio of negative sentiments (**Figure 7C**). Student recommendations, which increased in volume towards the end of the study, tended to request more events that brought each class together to collaborate. We additionally included questions gauging students' confidence to assess whether reduced self-efficacy is detectable in short-response questions. By partitioning these data between male and female students, we validated that female students expressed increased negatively connotated words compared to male students (**Figure 10D**). These data provide additional validation that low self-efficacy and low confidence exist in the same sphere.

4. Conclusions

Diversity within the classroom is crucial to creating a more inclusive environment with more varied perspectives. As reported here, a very limited set of conclusions can be derived from data that fails to include a diverse cohort. The most significant conclusions are observable from a reorganization of the data with respect to male and female students, which could potentially be a consequence of a relatively equivalent population of students in each group. Regardless, lower confidence and self-efficacy are observed in each cohort for female students, which does not appear to improve upon completion of the project. This suggests that the project is not sufficient for instilling a degree of confidence in using EML skills for female students in particular although the impact on male students is also not incredibly impressive. Notably, this dataset is based on a biomedical engineering cohort and additional studies including other fields of engineering is required to make comprehensive conclusions. Particularly, industrial or mechanical engineering cohorts, which tend to have larger male:female representation disparities should be assessed. Based on student suggestions, it is possible that including modules that require collaboration or communication across the entire cohort may be more desirable compared to small, static groups.

While the results of this study identify areas of the project that may be improved upon, a broader survey of classes or programs as a whole would be informative for generating a more inclusive BMEG program.

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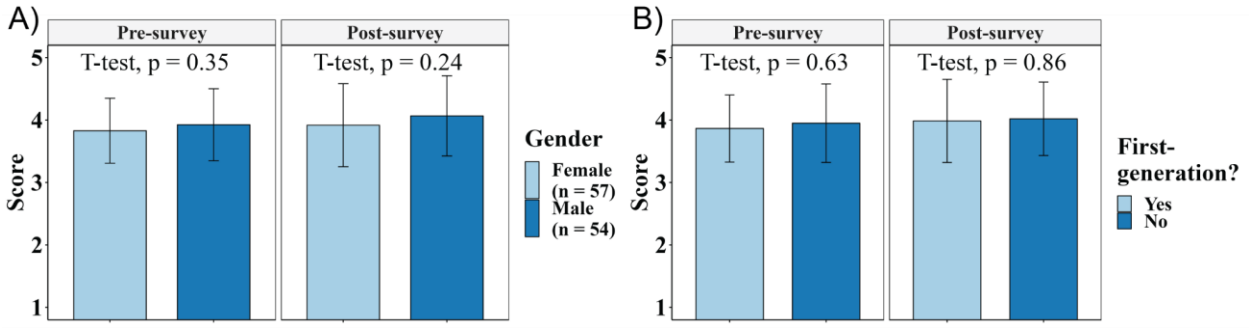
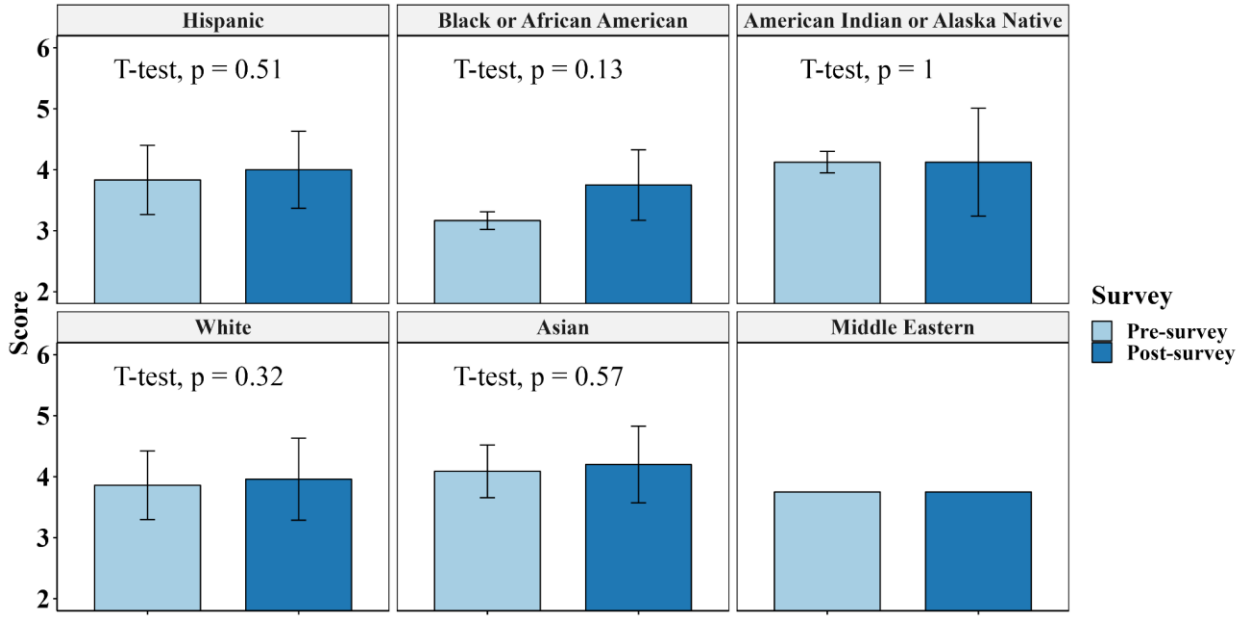
Supplementary Materials



Supplementary Figure 1: Occupational motivation scores for the financial and professional benefits of biomedical engineering demonstrate no difference or change for both A) male and female students and B) FGC and non-FGC students.



Supplementary Figure 2: Occupational motivation scores for the financial and professional benefits of biomedical engineering demonstrate no significant difference or change between each race.

Pre-survey:

Q1 Name

_____

Q2 [] email address

_____

Q3 Race

- White (9)
- Black or African American (10)
- American Indian or Alaska Native (11)
- Asian (12)
- Native Hawaiian or Pacific Islander (13)
- Hispanic (15)
- Other (14)

Q4 Are you a first-generation college student?

- Yes (1)
- No (2)

Q5 Gender

- ○ Male (9)
- ○ Female (10)
- ○ Non-binary / third gender (11)
- ○ Prefer not to answer (13)

Q6 Please indicate whether you agree or disagree with the following questions below.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I can design products to solve a real-world problem. (2)	○	○	○	○	○
I can think creatively to solve problems. (3)	○	○	○	○	○
I feel as smart as others. (4)	○	○	○	○	○
I can improve products based on testing. (5)	○	○	○	○	○
I definitely could become an engineer. (6)	○	○	○	○	○

I definitely could become an inventor. (7)	○	○	○	○	○

Q7 Being a male or female, being part of an ethnic group, being a member of your family, etc. may be an important part of how you see yourself. Please indicate how true each statement is.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I am motivated by the similarity I share with other students in my major (1)	○	○	○	○	○
I am motivated by my family nationality and/or nationality origin. (2)	○	○	○	○	○
I am motivated by my gender group. (3)	○	○	○	○	○
I am motivated by the membership I have as part of a student organization. (4)	○	○	○	○	○
I am motivated by my racial group. (5)	○	○	○	○	○

Q8 Please indicate the extent to which each of the following items corresponds to one of the

reasons why you chose your major.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
Because with only a high-school degree I would not find a high-paying job later on. (1)	○	○	○	○	○
Because I think that a college education will help me better prepare for the career I have chosen. (2)	○	○	○	○	○
For the pleasure I experience when I discover new things never seen before. (3)	○	○	○	○	○
For the pleasure that I experience in broadening my knowledge about subjects which appeal to me. (4)	○	○	○	○	○

Q9 Please indicate whether you agree or disagree with the following statements below.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)

I can understand the motivations and perspectives of customers (6)	○	○	○	○	○
I know how to make connections with what I learn in class and the real-world engineering problems (7)	○	○	○	○	○
I have the ability to make connections (8)	○	○	○	○	○
I know how to explore alternatives or encourage forming contrarian views of accepted solutions (1)	○	○	○	○	○
I can collaborate in a team setting (3)	○	○	○	○	○
I can communicate engineering solutions in economic terms (9)	○	○	○	○	○

I can substantiate claims with data and facts (10)	○	○	○	○	○

Q10 Please indicate whether you agree or disagree with the following statements.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I am sure in my ability to provide relevant solutions as an engineer (1)	○	○	○	○	○
I am sure in my ability to create value for a customer (3)	○	○	○	○	○
I understand the importance of creating value while conducting engineering problem solving (5)	○	○	○	○	○
I am sure in my ability to use customer opinions to give a valuable solution (7)	○	○	○	○	○

I can understand the motivations and perspectives of customers (9)	○	○	○	○	○
I am sure in my ability to create value in different situations (10)	○	○	○	○	○

Q11 Please indicate whether you agree or disagree with the following statements below.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I can apply learning in a new context (1)	○	○	○	○	○
I wish to learn beyond the course content curriculum (2)	○	○	○	○	○
I can formulate questions and generate own inquiries (3)	○	○	○	○	○
I show more curiosity about the worldly engineering problems (4)	○	○	○	○	○

I enjoy thinking in more innovative ways (6)	○	○	○	○	○
I understand the importance of learning new skills (7)	○	○	○	○	○
I like to exercise my curiosity about the surrounding world (8)	○	○	○	○	○

Q12 Do you have any interest in developing an invention or device?

○ Yes (4)

○ No (5)

Q13 How much do you understand about the invention process? i.e. documentation, the Food and Drug Administration (FDA), applying for patents...

_____

Q14 Have you taken a course before that emphasized problem-solving skills connecting to the real-world? If yes, please provide brief information about this course.

_____

Q15 How does your perception of entrepreneurship knowledge factor into your current and future career goals?

_____

Q16 How has your familial background influenced your knowledge of the value of entrepreneurial skills?

_____

Q17 What kind of programs/ events would you like to see offered by the department/college/university?

_____

Q18 Please provide any suggestions/comments you may have about the course project.

Post-survey:
Q1 Name

_____

Q2 [] email address

_____

Q3 Race (Select each that apply)

- ☐ White (9)
- ☐ Black or African American (10)
- ☐ American Indian or Alaska Native (11)
- ☐ Asian (12)
- ☐ Native Hawaiian or Pacific Islander (13)
- ☐ Hispanic (15)
- ☐ Other (Please enter your race here) (14)

_____

Q4 Are you a first-generation college student?

- ○ Yes (1)
- ○ No (2)

Q5 Gender

- Male (9)
- Female (10)
- Other (15)

Q35 Do you identify as a member of the LGBTQIA community?

- Yes (1)
- No (2)

Q6 Please indicate whether you agree or disagree with the following questions below.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I can design products to solve a real-world problem. (2)					
I can think creatively to solve problems. (3)					
I feel as smart as others. (4)					
I can improve products based on testing. (5)					

I definitely could become an engineer. (6)	○	○	○	○	○
I definitely could become an inventor. (7)	○	○	○	○	○
I understood what was required for this project to be successful. (1)	○	○	○	○	○

Q7 Being a male or female, being part of an ethnic group, being a member of your family, etc. may be an important part of how you see yourself. Please indicate how true each statement is.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I am motivated by the similarity I share with other students in my major (1)	○	○	○	○	○
I am motivated by my family nationality and/or nationality origin. (2)	○	○	○	○	○
I am motivated by my gender group. (3)	○	○	○	○	○

I am motivated by the membership I have as part of a student organization. (4)	○	○	○	○	○
I am motivated by my racial group. (5)	○	○	○	○	○

Q8 Please indicate the extent to which each of the following items corresponds to one of the reasons why you chose your major.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
Because with only a high-school degree I would not find a high-paying job later on. (1)	○	○	○	○	○
Because I think that a college education will help me better prepare for the career I have chosen. (2)	○	○	○	○	○

For the pleasure I experience when I discover new things never seen before. (3)	○	○	○	○	○
For the pleasure that I experience in broadening my knowledge about subjects which appeal to me. (4)	○	○	○	○	○

Q9 Please indicate whether you agree or disagree with the following statements below.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I understand the motivations and perspectives of customers (6)	○	○	○	○	○
I know how to make connections with what I learn in class and the real-world engineering problems (7)	○	○	○	○	○
I have the ability to make connections (8)	○	○	○	○	○

I know how to explore alternatives or encourage forming contrarian views of accepted solutions (1)	○	○	○	○	○
I can collaborate in a team setting (3)	○	○	○	○	○
I can communicate engineering solutions in economic terms (9)	○	○	○	○	○
I can substantiate claims with data and facts (10)	○	○	○	○	○

Q10 Please indicate whether you agree or disagree with the following statements below.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I am sure in my ability to provide relevant solutions as an engineer (1)	○	○	○	○	○
I am sure in my ability to create value for a customer (3)	○	○	○	○	○

I understand the importance of creating value while conducting engineering problem solving (5)	○	○	○	○	○
I am sure in my ability to persist through and learn from failure (7)	○	○	○	○	○
I understand the motivations and perspectives of customers (9)	○	○	○	○	○
I am sure in my ability to create value in different situations (10)	○	○	○	○	○

Q11 Please indicate whether you agree or disagree with the following statements below.

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)
I can apply learning in a new context (1)	○	○	○	○	○

I have furthered my learning beyond the course content curriculum (2)	○	○	○	○	○
I can formulate questions and generate own inquiries (3)	○	○	○	○	○
I show more curiosity about the worldly engineering problems (4)	○	○	○	○	○
I enjoy thinking in more innovative ways (6)	○	○	○	○	○
I understand the importance of learning new skills (7)	○	○	○	○	○
I can exercise curiosity about the surrounding world (8)	○	○	○	○	○

Q12 How has this project impacted your mindset?

_____

Q13 Have you gained any new mental habits? If yes, explain.

_____

Q14 How has this project impacted your engagement with your academic major?

_____

Q15 How has this project impacted your confidence in your academic major?

_____

Q16 Based on this project, in what ways are you more curious about the surrounding world?

_____

Q17 Has this project equipped you with the tools needed to create value in any context? Give examples and explain.

_____

Q18 How has this project effected how you make connections about the surrounding world? Give examples and explain.

_____

Q19 What kind of programs/ events would you like to see offered by the department/college/university?

_____

Q20 Please provide any suggestions/comments you may have about the course project.

_____

Q21 Please read the informed consent form using the below link. If you agree to participate in this important research, then simply click the arrow below to submit your survey. If, however, you choose not to include your responses in our research, please notify Dr. [] via the contact information in the consent form.