Board 141: Work in progress: Investigating Historically Marginalized Group Disparities in Biomedical Engineering Entrepreneurially Minded Learning

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Introduction

The tenets of entrepreneurial-minded learning (EML) facilitate the connection between the understanding of fundamentals and applying such knowledge to develop solutions generating economic or social value. As a result, EML is a promising candidate for integrating entrepreneur and industry-oriented thinking into engineering education [1–3]. Current biomedical engineering (BMEG) pedagogies consist of problem-based learning content. However, current industry trends are beginning to necessitate increasingly quick and innovative thinking from engineers [4]. Furthermore, the BMEG field has a particular need for incorporating more application-based concepts due to an intrinsically multidisciplinary nature causing a limitation of curriculum space. One solution to this limitation is to integrate complementary content to enhance the understanding of course concepts without excising existing course materials. We previously developed a semester-long EML project directing students on the process of product development in a sophomore-level Biomechanics course. Using this project, we demonstrated in past studies that the inclusion of EML in a project can significantly enhance student self-evaluations for curiosity, connections, and value creation compared to a control group of students provided with the same project lacking explicit instructions to include EML concepts [5].

The incorporation of entrepreneurship skills in biomedical engineering curricula is critical for promoting discovery and broadening student perspectives on industry applications. However, representation among existing examples of inventors and entrepreneurs is heavily biased toward White and Asian males [6,7]. Historically marginalized minorities (HRMs), including women and first-generation college students (FGCs), are underserved in upper-level education systems. The consequences of such systemic bias, including the unintentional usage of exclusive educational materials, have a particularly negative impact on the biomedical engineering field because education inclusivity and the patients to which the biomedical field serves are limited for HRMs [8].

To diagnose the impact of current EML course materials on HRM students, which is defined here as students of marginalized races in addition to female students and FGCs, we distributed the version of our project incorporating EML skills to a new cohort of students and examined whether a significant differential in effectiveness was conferred. For the control group, demographic data were not collected and are not available for this study. Due to the broad overall impact of our project on developing student EML skills, we propose continuing to incorporate this project into our coursework and further analyzing the impact of current EML implementations on a larger sample size of marginalized groups. These data will inform the types of improvements that are needed to best promote diversity within BMEG students and increase the availability of EML skills for HRMs. Following analysis of a larger sample size, course material inclusivity will be further examined on a larger scale in multiple course modules intending to impart EML skills.
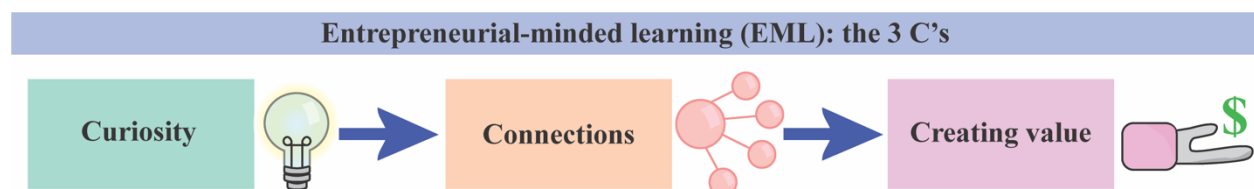
Curriculum Development and Preliminary Data

Figure 1: A) EML is based on the acquisition of the 3 C's: curiosity, connections, and creating value.

The EML project (**Figure 1**) consists of three modules providing students with two patient cases requiring a hip or knee implant for which they will develop a comprehensive treatment plan. In the previous study, students in the control group are provided with the patient profile without any additional prompting from the project brief. However, students in the EML group were given specific requirements soliciting the usage of EML skills including curiosity, making connections, and creating value out of the project premise. In the current study, the project explicitly encouraging EML skill incorporation was solely used. Re-examining the EML dataset with respect to race and gender illustrated a differential pattern that warrants investigation.
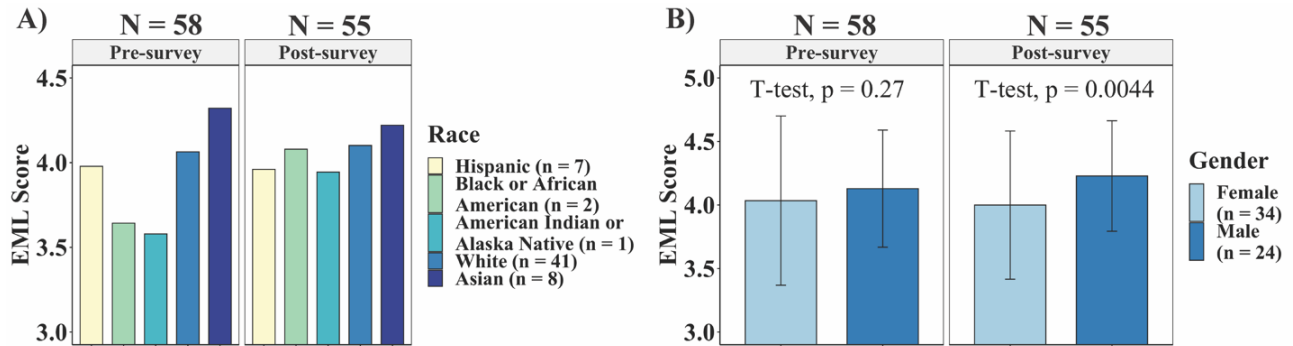

Figure 2: A) EML scores organized with respect to race based on a Likert scale evaluating student acquisition of the 3 C's before and after assignment completion. B) EML scores organized with respect to gender based on a Likert scale evaluating student acquisition of the 3 C's before and after assignment completion.

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 2A**). However, the final EML score of HRM students after assignment delivery was lower than that of well-represented students (**Figure 2A**). 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.

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 2B**). 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. 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.
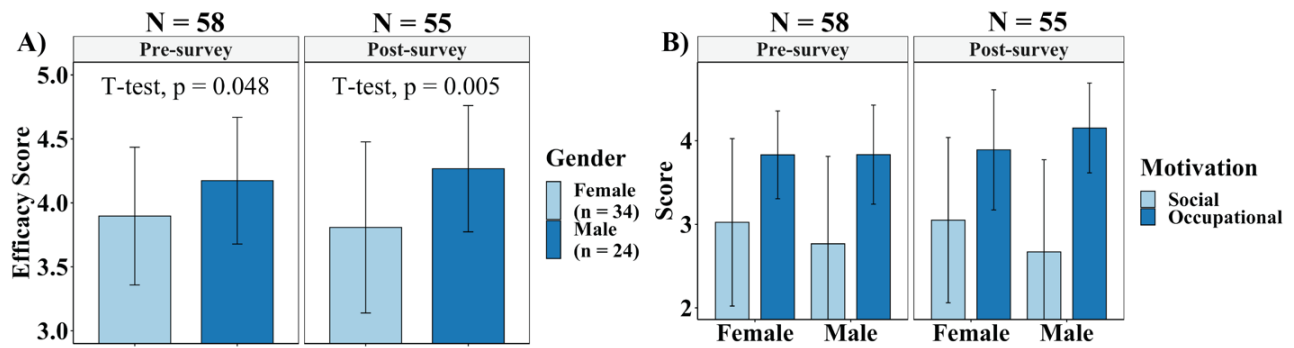
Figure 3: A) Efficacy scores based on a Likert scale with respect to gender identifies a significant reduction of efficacy in female students. B) Ranking motivation sources categorized as either socially or occupationally embedded demonstrates no significant difference across gender.

Based on gender, a significant reduction in efficacy was observed in female students both before and after assignment delivery, which is an observation corroborated by studies gauging self-efficacy in female entrepreneurs in general (**Figure 3A**) [9]. Efficacy post-assignment was additionally lower than pre-assignment delivery for female students, which indicates that a belief in individual academic success may have reduced after completing the project (**Figure 3A**). As male students did not experience a similar reduction, this is a concerning outcome. Motivation sources, however, were more homogenous across gender groups with social motivation remaining low in both pre- and post-assignment delivery (**Figure 3B**). Organizing survey responses with respect to ethnicity produced more differential scores with generally lower efficacy in HRMs, but conclusions with sample sizes as low as a single student are insufficient to create a comprehensive conclusion. These analyses with respect to gender will be replicated among ethnicity groups after collecting an additional cohort of data to compensate for the currently low sample sizes.

Evaluations

The initial results of this study have motivated a more in-depth investigation between multiple cohorts of students. Our previously designed EML project will be re-distributed to another cohort of students to obtain a larger dataset providing additional information regarding content inclusivity. A survey will be distributed before and after assignment delivery to ascertain whether a differential impact of EML content can be attributed to content exclusivity. Open responses gauging the perceived social implications of the project and the student perspective on the project as a method of increasing entrepreneurship accessibility will be analyzed in both HRM and non-HRM groups. The resulting survey responses will be organized with respect to three demographics: ethnicity, gender, and first-generation students pursuing a bachelor's degree. In addition to obtaining a larger sample size of responses, methods will be developed to quantitatively analyze open responses providing feedback on the effectiveness of the EML project and to what extent students believed their background influenced this experience. We will additionally report a consensus on student recommendations for programs or resources that the university should supply to further support HRMs. This work underscores the importance of incorporating EML material for HRM groups and further diagnoses the presence of content exclusivity in EML-based projects.

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