Toward Equity and Inclusivity in Engineering Classrooms: Understanding Students' Disparities in Response to Clinical Observations and Needs-Finding Course Development

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Abstract:

A central theme to the field of biomedical engineering is the ability to identify clinical problems and propose and develop engineering approaches to solving these problems. To train students in developing these skills, our department has developed a clinical and industry immersion course that serves as a pre-requisite to the senior design course in the undergraduate curriculum. The specific content and efficacy of these types of courses are likely to vary significantly depending on a range of factors, including the Institutions' access to academic medical centers and biomedical industry sites proximate to their location, as well as the specific demographic composition of the student body. The field of biomedical engineering-as in other fields of engineering- broadly exhibits particular demographics that differ from that of the general population. As a result, students from certain underrepresented groups may experience disparate learning outcomes from these types of courses, and strategies to improve clinical immersion courses for these groups are limited in the engineering education literature. A major focus of this study was to quantify how our clinical immersion course impacts students from historically marginalized groups in race, ethnicity, first-generation status, gender, and age. Comparisons were made between historically marginalized groups such as African Americans, Hispanics, women, and first-generation college students and their dominant counterparts. Pre- and post-course Likert scale questions were used to analyze the student's sense of self-efficacy, abilities to make connections and create value, and general interests in engineering. Preliminary data analysis indicated that there are discrepancies in the results of different demographic groups. Further analysis will be conducted to reveal the intricacies of the relationship between historically marginalized groups and their experiences in this class. A qualitative analysis software will be used to evaluate the open-response questions between these groups to more clearly identify which factors are most influential for students' learning outcomes and sense of belongingness in the field. This study intends to understand the differential impacts of a service-learning course on historically marginalized groups, in an attempt to improve the equity and quality of our curriculum.

Introduction:

Needs identification and solution development are two of the core skills to be developed by biomedical engineering students during their undergraduate education. While needs identification may occur through literature reviews and background research, in-person clinical experience is more valuable [1], [2]. We have developed a junior-level Clinical Observations and Needs Finding course as a pre-requisite to the Senior Design course. Our course is designated as a service-learning course, as it requires students to complete immersive, clinical visits with local healthcare and industry partners. In a previous study, the efficiency of this course was evaluated through pre—and post—course surveys that utilized Likert scale and open-ended questions. It was determined that the course was successful in increasing students' self-efficacy as it relates to the engineering design process, their ability to make connections with customers, and their understanding of value creation.

The field of biomedical engineering manifests demographics that are not necessarily representative of the general population [3], [4]. As a result of this, historically marginalized groups may experience disparate learning challenges in higher education and the workforce. Research has suggested several reasons why historically marginalized groups do not enter the engineering disciplines or choose to leave. These include unwelcoming climates, negative

interactions with professors and peers, and a lack of sense of belonging [5]. While some professionals have adopted a “colorblind” mindset in an attempt to not discriminate between students of different racial backgrounds, this has been shown to produce the opposite effect. By attempting to see past race, professors of historically non-marginalized groups inadvertently advantaged students of their own background [6]. Some schools have developed programs that attempt to increase the feeling of belonging for historically marginalized groups, but most of these interactions occur outside the classroom [3]. The purpose of this study is to quantify and evaluate the efficacy of a clinical observations and needs-finding course on historically marginalized groups, to create a more welcoming and equal learning environment.

Methods:

To measure students’ perceptions before and after completing the course, a Qualtrics survey was created with Likert scale questions and open-response questions that directly aligned with the course objectives as stated in the syllabus. The survey was administered to all 75 junior-level undergraduate students during the first and last weeks of the course. Microsoft Excel was used to graphically analyze the Likert scale questions. Demographic information was collected at the beginning of the survey, including gender, race, ethnicity, age, and first-generation status. The questions evaluated the students’ confidence levels in various areas, including abilities to make connections to communicate solutions. The raw data was sorted into two groups by race: historically marginalized groups included black, American Indian/ Alaskan Native, and other, while non-historically marginalized groups included white and Asian students. The analysis of the open-response questions will be performed using NVivo, a qualitative analysis computer software that allows researchers to decrease the potential impact of bias. The Institutional Review Board (IRB) approved the current study (IRB protocol #: 2209420237).

Results:

The preliminary results of the survey indicate that there are differences in engineering-related responses between historically marginalized groups (HMG) and non-historically marginalized groups (NHMG). Survey questions prompted students to assess their proficiency in various engineering-related skills to quantify their confidence levels. Overall, average confidence levels for both groups increased after completion of the course, indicating a positive effect of the course on students.

The results of Questions 1 and 2 are shown in Figure 1. HMG's Question 1 results post-course revealed a 50% rise in the "Agree" response and a new 12.5% response for "Strongly Agree," indicating increased confidence in articulating engineering solutions in economic terms. Similarly, NHMG exhibited a notable boost in confidence regarding communication of engineering solutions in economic terms; however, NHMG demonstrated a higher percentage of "Strongly Agree" responses in both pre-and post-course surveys than HMG. This trend of overall higher confidence levels post-course for both groups but a more intense, higher confidence response in NHMG is translational across all questions. Question 2 HMG results post-course depicted a new response of 25% in the “Strongly Agree “response. Likewise, NHMG results post-course exhibited a more modest increase of 16% in the “Strongly Agree” response.

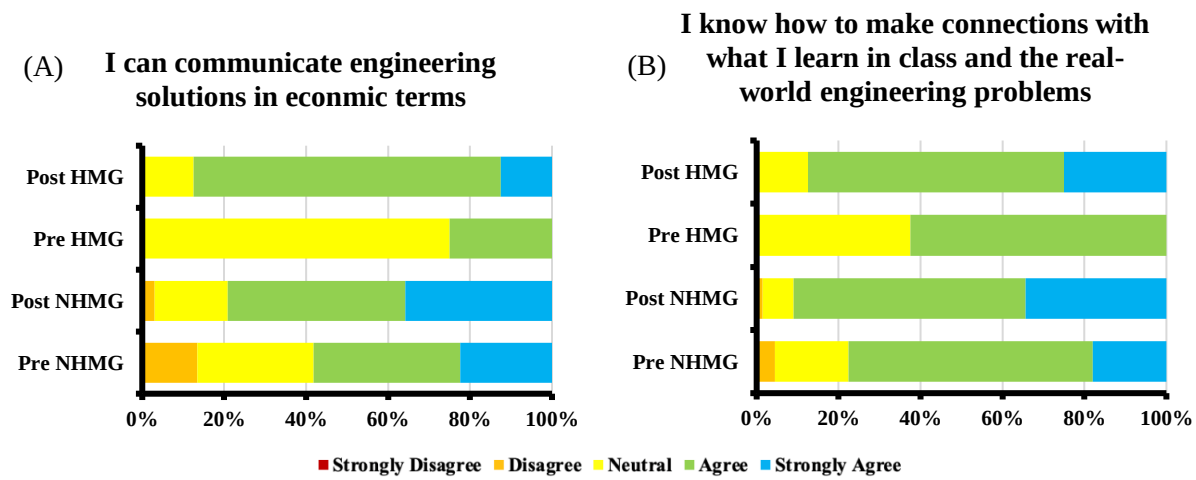

Figure 1: The results of Question 1 (A) and Question 2 (B) from the pre- and post-course surveys.

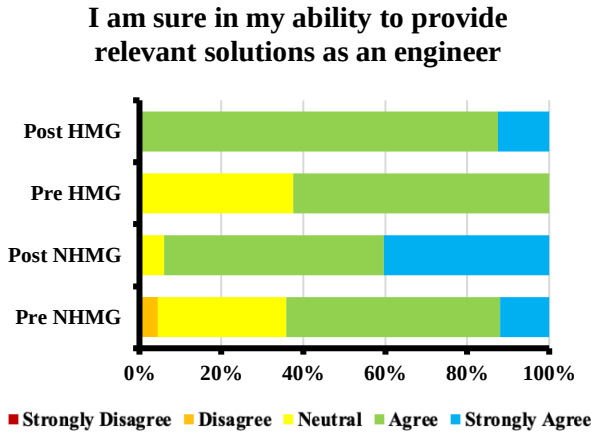

Figure 2: The results of Question 3 from the pre- and post-course surveys.

Question 3 evaluated the students' abilities to provide relevant solutions to problems identified during their experiences. Before the course, no HMG reported to strongly agree with the statement, a trend from Questions 1 and 2. Following the course, 12.5% of HMG students strongly agreed and the remaining 85% agreed with the statement. There is a clear and notable difference between HMG and NHMG in all three questions.

This is a longitudinal study that aims to track the efficiency of the Clinical Observations and Needs Finding course over time. Preliminary data suggests that while HMG students are succeeding in the course by growing in confidence, they are entering with differing, less confident, mindsets than their NHMG counterparts. Limitations of this study include disaparities between the sample size of HMG and NHMG. In the future, NVivo analysis of survey questions will be conducted to gain qualitative results. This may offer a richer understanding of students' experiences/perceptions, providing insights into the factors influencing confidence levels among HMG. With the results, implementing intervention strategies aimed at promoting diversity and inclusion within engineering education may be the answer to closing the gap in confidence disparities between NHMG and HMG. Additionally, in future iterations of the survey, students may be asked to explain their reasonings for such answers.

References:

[1] B. Przestrzelski and J. D. DesJardins, "The DeFINE Program: A Clinical Immersion for Biomedical Needs Identification," presented at the 2015 ASEE Annual Conference & Exposition, Jun. 2015, p. 26.1514.1-26.1514.16. Accessed: Jan. 18, 2024. [Online]. Available: https://peer.asee.org/the-define-program-a-clinical-immersion-for-biomedical-needs-identification

[2] M. Kotche, "Clinical Immersion Internship Introduces Students to Needs Assessment," presented at the 2016 ASEE Annual Conference & Exposition, Jun. 2016. Accessed: Jan. 18, 2024. [Online]. Available: https://peer.asee.org/clinical-immersion-internship-introduces-students-to-needs-assessment

[3] M. Ong, J. M. Smith, and L. T. Ko, "Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success," *J. Res. Sci. Teach.*, vol. 55, no. 2, pp. 206–245, 2018, doi: 10.1002/tea.21417.

[4] K. C. Thiem and N. Dasgupta, "From Precollege to Career: Barriers Facing Historically Marginalized Students and Evidence-Based Solutions," *Soc. Issues Policy Rev.*, vol. 16, no. 1, pp. 212–251, Jan. 2022, doi: 10.1111/sipr.12085.

[5] S. C. Davis, S. B. Nolen, N. Cheon, E. Moise, and E. W. Hamilton, "Engineering climate for marginalized groups: Connections to peer relations and engineering identity," *J. Eng. Educ.*, vol. 112, no. 2, pp. 284–315, Apr. 2023, doi: 10.1002/jee.20515.

[6] M. G. Eastman, M. L. Miles, and R. Yerrick, "Exploring the White and male culture: Investigating individual perspectives of equity and privilege in engineering education," *J. Eng. Educ.*, vol. 108, no. 4, pp. 459–480, Oct. 2019, doi: 10.1002/jee.20290.