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Gender Awareness in STEM Education: Perspectives from Adolescents, Teachers and Mentors in a Summer Pre-college Engineering Program (Work in Progress)

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Abstract

This multi-methods study explored gender awareness in a summer pre-college engineering program (PREP) in Southwestern U.S. Survey data were collected from 238 middle and high school-age adolescents, 11 teachers, and 17 mentors. Statistical analyses of the selected response data revealed a significant difference between female and male students and mentors in their responses. Analysis of the open-ended responses also indicated that all stakeholders would like to see more presentations, discussion, and speakers that integrate gender awareness and a higher representation of females and diverse genders (e.g., LGBTQ+) in the program. Nonetheless, some participants expressed concerns with discussions on gender-related topics, believing that the discussions would make the “objective” STEM too political. These results highlighted the need to improve pre-college programs by making conversations about gender explicit and normative in order to challenge dominant discourses of engineering and help females see themselves reflected in engineering careers.

Keywords: PREP, Gender Awareness in STEM, Pre-College Engineering Program, STEM Education

Background

Recent data from National Center for Education Statistics High School Longitudinal Study revealed an appalling gender gap in adolescents' intent to major in STEM [1]. To address this gap, pre-college engineering programs play an important role by recruiting, encouraging, and maintaining female students' interests in STEM. Research has identified some effective practices to recruit girls in secondary schools into STEM majors, such as summer programs with gender parity (50% girls) [6]. However, such practice may only be effective when the programs also raise awareness of gender stereotypes and perceived gender roles that have an impact on STEM motivation and engagement [2, 7]. Even with a developed interest in STEM, female students are faced with multiple barriers, such as being outnumbered by male counterparts and having few same-sex role models and mentors [5].

Faulkner [8, p. 278] proposes a reflection on how the concept of gender (in)authenticity consistently and inconsistently impacts both men and women as a result of normative cultural ideologies that sustain "the way things are". (In)authenticity of gender is the result of norms that impact the identity formation of engineers while continuing the tradition of men as the universal face of engineering. These cultural ideologies enable the establishment of a dominant discourse where beliefs, attitudes, behaviors, and even daily language have been used to frame social dynamics and advance the careers of males in engineering. Moreover, research indicates that these ideologies can lead to a conflict of gender authenticity for females who want to become engineers, while symbolizing a natural choice for men. A challenge to "women into engineering" requires us to foreground and celebrate heterogeneities in genders in engineering [9, p. 333]. In

engineering education, an analytical abstract approach is privileged, while social topics, though applied to all engineers in practice, are rarely presented. As part of a larger program evaluation research, the current study explores gender awareness of multiple stake-holders (adolescents, teachers, and mentors) in a summer Pre-college Engineering Program (PREP). Our study was guided by the overarching research question: What are stake-holders' perspectives on promoting gender awareness in this pre-college engineering program?

Method

Participants

Participants included 238 middle (60%) and high (40%) school students who self-identified as 97 females, 129 males, and 12 other genders. The majority of the students came from a Hispanic ethnic background (42%), followed by Asian (27%), White (14%) Black or African American (5%) and Biracial/Multiracial (5%). The student sample is predominantly middle class. Seventy percent of students have at least one parent holding a college degree or higher. Other participants included eleven teachers (4 females, 7 males, average age 49 years) and 17 mentors (7 females, 10 males, average age 22 years) in the summer program.

Data collection and analysis approach.

As a part of a larger program evaluation survey study, we asked students, teachers and mentors to rate the same three gender-related Likert Scale (1-5) items about the curriculum, career speakers, and the overall program effectiveness in gender representation. In addition, participants were asked to respond to a qualitative open-ended question --"What else could the program (PREP) do to promote gender equity and awareness?" All surveys were administered via Qualtrics and collected virtually. Preliminary analysis of data includes descriptive statistics of the Likert-scale items and qualitative two-cycle coding methods. Independent sample t-tests were conducted between male and female adolescents to explore gender differences in perceived effectiveness of gender representation in the program. For responses to the open-ended questions, we employed a ground-up approach by grouping comments into themes and developing codes based on the data and themes in the first coding cycle. In the second cycle, we applied the codes systematically to all data.

Results

Quantitative results (Likert-scale survey items)

We asked all participants to rate PREP program effectiveness in promoting gender awareness and equity. Table 1 presents the means (M) and standard deviations (SD) of the ratings (on a scale 1-5) by three stake-holder groups by gender. Participants rated PREP positively in its effectiveness in promoting gender awareness and equity. However, there are discrepancies across items and participant groups. Descriptively, teachers and mentors rated most items slightly higher than students. Female students consistently rated all items slightly higher than the male students, who gave higher ratings than students of other gender identities. For the item "PREP is effective in promoting gender representation," independent sample t-tests also revealed a

statistically significant difference between female and male students in their ratings (t = -2.719, p = .004, df = 224).

This gender difference trend was reversed in the mentors' responses. On average, female mentors rated all questions lower than male mentors. Among the three items, the item -- "The PREP curriculum talked enough about gender topics" received the lowest ratings by all participant groups, revealing a strong need to include gender topics in the curriculum.

Table 1
Mean and Standard Deviations of the PREP Program Effectiveness in Promoting Gender Awareness by Students, Teachers, and Mentors

	Student (n=238)			Teacher (n=11)		Mentor (n=17)	
	Female (n=97)	Male (n=129)	Other (n=12)	Female (n=4)	Male (n=7)	Female (n=7)	Male (n=10)
1. The PREP curriculum talked enough about gender topics.	3.18 [1.041]	2.98 [.879]	2.75 [1.084]	3.25 [.500]	3.29 [.951]	2.57 [.976]	4.10 [1.197]
2. PREP career speakers were diverse in gender and promoted gender equity in STEM.	4.07 [.869]	3.95 [.913]	3.50 [1.000]	4.50 [.577]	4.14 [.900]	3.57 [.976]	4.60 [.516]
3. PREP is effective in promoting gender representation.	3.89* [.934]	3.55* [.901]	2.92 [1.084]	4.25 [.957]	4.14 [1.215]	4.14 [.690]	4.60 [.699]

Note 1. All participants evaluated program effectiveness for all questions on a Likert-scale (1-5)
Note 2. Independent sample t-test between female and male students was significant

Qualitative results (responses to open-ended questions)

We analyzed participants' responses to the open-ended questions and identified three main themes. Results from the data also showed an interesting gender difference, with female students being more likely to give specific suggestions in promoting gender equity compared to male students. More male participants showed indifference about the topic and/or suggested that "gender awareness is not a part of STEM" (Student ID 147, male). This finding seemed to contradict to the quantitative finding that male students were less likely to be satisfied with the program effectiveness in gender awareness. Further comparisons of the students' ratings and their qualitative responses revealed that participants who showed indifference or annoyance with gender topics in their comments tended to rate the Likert-Scale items for gender topics lower (1-2) or neutral (3). This indicated that students' evaluation of the program effectiveness in promoting gender awareness was greatly influenced by their own attitudes towards gender topics in STEM. Negative attitudes towards gender topics may lead to lower ratings of statements related to gender awareness.

Theme 1: More presentations and explicit discussions about gender equity

A total of 71 students (34 females, 33 males, 4 other genders) expressed the need to include more presentations and discussions and inviting more speakers to talk specifically about gender issues. "PREP could have a guest speaker talk about gender equity. The guest speaker could be someone who is deeply involved with gender studies or our counselor, Mrs. xxx" (Student ID 57, male). The topics of such presentations may range from "women and men both making impacts in the workplace" (Mentor ID 9, female) to the "the history behind the knowledge that we are learning and describe the diverse figures that were actively involved in shaping the knowledge we know today" (Student ID 154, non-binary). Bringing knowledgeable speakers and having explicit discussions bring awareness to the heterogeneities in engineering and shift the perspectives from STEM as technical practice to STEM as a social practice of technical skills. Such shifts may require a fundamental change in the PREP curriculum and experts to train all teachers and staff. Even though Teacher ID 3 (male) realized the importance of focusing on gender and equity, he was challenged by a lack of training and time to prepare the curriculum. The fundamental issue lies in the "gender-neutral" technical approach in state content standards as well as the training and support.

Theme 2: More representations of females and respect diverse gender categories

Thirty-three students (20 females, 12 males, and 1 binary) mentioned the need for more females or individuals with other gender identities to be represented as students, staff, or guest speakers in the program. "I think that PREP could get more female speakers to talk to the students, and I think that if you encourage people to talk about the challenges they had…could help promote awareness" (Student ID 133, female). The gendered view of engineering is rooted in its participants even with awareness and gender equity in mind. The male dominance of engineering is perceived to be a challenge in increasing diversity in career speakers (see Excerpt 2).

Excerpt 2
"Engineering is traditionally a male-dominated career field. PREP itself promotes gender equity and awareness by its selection of administrators, staff, instructors, program assistants, and students who come from diverse backgrounds. The challenge remains to increase the invitation of speakers and to offer field trips with such diversity in mind."

In addition, twenty-five students (15 females, 5 males, and 5 other genders) called for more space for diverse gender identities and practice respect in everyday program functions. Moving away from binary identification of gender challenges the gender duality of engineering and creates a safe space for people of diverse identities. Student ID 59 (other gender) emphasized the importance of inviting participants to self-identify their gender and identity– " I just am very happy when someone just asks how I identify (like if I had a nickname), it's not really for me, but it lets me know that it's commonplace to ask and respect that; make it a normality."

Theme 3: "Gender is not part of STEM"

A total of 21 students (4 females, 17 males) shared their concerns about discussing gender in STEM. Most of these students wrote "just here to learn, not comfortable about this

topic"(Student ID 10, female) with a shared belief that "gender awareness is not a part of STEM" (Student ID147, male) and "not a question that children should be asked" (Student ID 110, male). This perspective is dominant among male adolescents, such as student ID 158 (see Excerpt 3).

Excerpt 3
"Sensible people come to this academic program in the hope to learn and expand their knowledge, not to have their self-identified gender propped up on a pillar and glorified for all to see. IT IS NOT THE JOB OF OTHERS TO GIVE UNCONDITIONAL PRAISE AND SUPPORT TO THE FEELINGS OF OTHERS. I, a kid going into 8th grade, have enough connections in my brain to see that this is idiotic on all fronts."

Some students were reluctant to discuss this topic from a "gender neutral" perspective. "They don't need to (talk about gender) because I already know that girls and boys are equal in science and prep has made it clear that girls can be as smart as boys or smarter than boys" (Student ID 235, female). This reluctance to see gender as relevant in their careers and workplaces was also observed in previous research [8]. This "discourse of gender neutrality — that everyone is being treated equally—amongst women and men scientists and engineers in the US" may yield a negative effect and perpetuate gender inequality [3]. Raising gender awareness in adolescents requires the buy-in from their teachers and mentors, yet not all teachers and mentors in our study acknowledged the social nature of engineering. For example, Teacher ID 9 (female) continuously rejected the social nature of engineering – "No idea - I didn't think about such things while instructing and would venture to guess most of the others did not either - it was the content that I focused on." A male Mentor ID 13 also shared the same belief that "the program realistically can't do anything else beyond an opportunity to learn about engineering, and to encourage students of all ages AND gender that they CAN become engineers."

Discussion and implications for engineering education

Gender disparities persist in STEM education for decades in spite of on-going effort in research and education interventions [4, 10]. Results from the study revealed the persistent cultural conditions and stereotypes that may lead to implicit biases and hostility towards stereotyped groups [10]. The findings of this study also highlighted stakeholders' voices and called for prioritizing gender equity in pre-college engineering education.

Although small-scale in nature, the current project contributes to the current STEM education in several ways. First, it extends the scope of pre-college engineering program evaluations to include the gender (in)authenticity of the program. Evaluation of STEM programs should include a critical examination of the dominant discourse where beliefs, attitudes, behaviors, and daily language are used to frame social dynamics in the program. The study also provides practical implications for education practices to raise gender awareness. These recommended practices, voiced by multiple stakeholders, include but not limited to: (1) explicitly discuss gender equity throughout the program; (2) present gender minorities' contribution in STEM throughout the history; (3) invite gender minoritized professionals share their challenges and experiences in their careers; (4) recruit more female or other gendered students, mentors, teachers, and guest speakers; (5) practice respect and inclusiveness in daily classrooms; (6) modify the content standards to include the social aspects of engineering; (7) incorporate social justice topics in

STEM curriculum, and (8) provide teachers and mentors with training on the social aspect of engineering. It is also worth noting that stakeholders' own ideologies of gender and positionality of gender awareness may interact with the program interventions. Broaching gender awareness in STEM education and community requires the buy-in of the stakeholders who are otherwise reluctant to be open to discussions about gender and social justice. The next step of this project is to develop interventions to raise gender awareness and examine the effectiveness of the interventions through constant feedback from stakeholders and community.

References

[1] W. Radford, L. B. Fritch, K. Leu, and M. Duprey, "High School Longitudinal Study of 2009 (HSLS: 09) Second Follow-Up: A First Look at Fall 2009 Ninth-Graders in 2016. ," *National Center for Education Statistics* , 2018. [Online]. Available: https://nces.ed.gov/pubs2018/2018139.pdf. [Accessed: 24-Jan-2022].

[2] L. McGuire, K. L. Mulvey, E. Goff, M. J. Irvin, M. Winterbottom, G. E. Fields, A. Hartstone-Rose, and A. Rutland, "Stem gender stereotypes from early childhood through adolescence at Informal Science Centers," *Journal of Applied Developmental Psychology*, vol. 67, p. 101-109, 2020.

[3] M. A. Eisenhart and E. Finkel, *Learning and succeeding from the margins.* University of Chicago Press, 1998.

[4] M.-T. Wang and J. L. Degol, "Gender gap in science, Technology, engineering, and Mathematics (stem): Current knowledge, implications for practice, policy, and Future Directions," *Educational Psychology Review*, vol. 29, no. 1, pp. 119–140, 2016.

[5] N. Dasgupta and J. G. Stout, "Girls and women in Science, Technology, engineering, and Mathematics," *Policy Insights from the Behavioral and Brain Sciences*, vol. 1, no. 1, pp. 21–29, 2014.

[6] N. Dasgupta, M. M. M. Scircle, and M. Hunsinger, "Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering," *Proceedings of the National Academy of Sciences*, vol. 112, no. 16, pp. 4988–4993, 2015.

[7] T. E. S. Charlesworth and M. R. Banaji, "Gender in science, technology, engineering, and mathematics: Issues, causes, solutions," *The Journal of Neuroscience*, vol. 39, no. 37, pp. 7228–7243, 2019.

[8] W. Faulkner, "Gender (in) authenticity, belonging and identity work in engineering," *Brussels economic review*, vol. 54, no. 2/3, pp. 277–293, 2011.

[9] W. Faulkner, "`nuts and bolts and people'," *Social Studies of Science*, vol. 37, no. 3, pp. 331–356, 2007.

[10] Y. Xie, M. Fang, and K. Shauman, "Stem education," *Annual Review of Sociology*, vol. 41, no. 1, pp. 331–357, 2015.