

UC Davis

UC Davis Previously Published Works

Title

Work in Progress: Fostering the Development of Engineering Identity in First-Year Women Engineering Students Through First-Year Seminars

Permalink

<https://escholarship.org/uc/item/9w82n41w>

Authors

Tamura, Angelika

Chan, Tiffany

Wang, Xianglong

Publication Date

2024-07-28

DOI

10.18260/1-2--48644

Copyright Information

This work is made available under the terms of a Creative Commons Attribution-NonCommercial-NoDerivatives License, available at <https://creativecommons.org/licenses/by-nc-nd/4.0/>

Peer reviewed

Work in Progress: Fostering the Development of Engineering Identity in First-Year Women Engineering Students Through First-Year Seminars

Angelika Aldea Tamura, University of California, Davis

Angelika Tamura is a third-year undergraduate student pursuing a B.S. in Biomedical Engineering at the University of California, Davis. She is a research assistant for the Cube3 lab, which primarily does research in engineering education. She is also deeply engaged in the Biomedical Engineering Society student chapter at UCD, where she serves as the vice president and actively contributes to the Outreach, Fundraising, and Picnic Day committees. Alongside her involvement in BMES, Angelika is an enthusiastic member of B-Hours, a student-run organization dedicated to projects benefiting clinics in Sacramento. Focusing her course studies in cell and tissue engineering, Angelika is currently seeking professional opportunities to further explore her passion in bioprinting and regenerative medicine.

Tiffany Marie Chan, University of California, Davis

Tiffany Chan is a 3rd-year undergraduate student in biomedical engineering at UC Davis and the recipient of the 2024 ASEE-PSW Section Undergraduate Student Award. She actively contributes to the cube3 Lab, where her interests lie in community building and inclusive practices. Tiffany is involved in various DEI (Diversity, Equity, and Inclusion) research initiatives within the lab, including organizing student-faculty lunches and participating in the gender equity first-year seminar program. Additionally, she serves as the chair of the undergraduate subcommittee for the department's Health, Equity, and Wellness committee and holds the position of president in the BMES student chapter at UC Davis.

Dr. Xianglong Wang, University of California, Davis

Dr. Xianglong Wang is an Assistant Professor of Teaching in Biomedical Engineering at the University of California, Davis. He is the principal investigator of the cube3 lab. The cube3 lab actively performs research in community building and gender equity in engineering, as well as problem-based learning in core biomedical engineering courses. Before joining UC Davis, he was a career-track Assistant Professor at Washington State University (WSU). Dr. Wang is the recipient of the 2024 ASEE-PSW Section Outstanding Early Career Teaching Award, 2023 UC Davis Biomedical Engineering Excellence in Teaching Award, and 2022 WSU Reid Miller Teaching Excellence Award. Dr. Wang received his Ph.D. in Biomedical Engineering and Scientific Computing from the University of Michigan.

Work in Progress: Fostering the Development of Engineering Identity in First-Year Women Engineering Students Through First-Year Seminars

Introduction

Being a woman in engineering is associated with numerous visible and invisible challenges including a chilly climate, lack of support, and the absence of role models [1, 2]. These challenges persist through every stage of a woman's engineering career, starting from their educational experiences, and extending well into their professional life, whether in industry or in academia. In the most recent national survey by American Society of Engineering Education [3], women make up 25.5% of the enrollment and 24.1% of the degrees awarded in engineering programs. A chilly climate [4] is often thought to be contributing to the lack of engineering identity within women in engineering, resulting in lower persistence, interest, and confidence in engineering disciplines [5, 6].

In the workplace, women engineers often face demoralizing interactions that challenge their engineering identities. Such interactions may include colleagues doubting their technical abilities, having their opinions ignored until a male engineer repeats them, and having to adopt a male-sounding name [7]. Systemic issues within academic institutions further exacerbate these challenges. According to a report from MIT [8], men form most of the departmental leadership positions in engineering and a severe stagnation exists in the growth of female faculty members within engineering departments. Additionally, men often receive more benefits and enjoy better, more family-oriented lifestyles compared to their female counterparts [8]. These experiences not only contribute to a heightened sense of marginalization and demoralization among aspiring women engineers but also create a hostile work environment that hinders their career progression and stunts their motivation to stay in the field.

These problems are reflected in persistent departures of women from the field of engineering, indicating an urgent need for intervention [9]. Many women cite personal misalignment with the field as the reason for their departure [9]. Furthermore, the number of women decreases dramatically as one moves up the industrial ladder. While women may enter engineering roles, they are less likely to ascend to higher-level positions, resulting in fewer female leaders and role models within the industry [10].

Our lab decided to address these challenges by developing a first-year seminar (FYS) designed specifically for women pursuing or aspiring to enter engineering. Through a robust and interactive curriculum, this seminar aims to confront the complexities of gender disparities in both engineering academia and industry while nurturing students to thrive in a supportive environment. Our goal is to create a welcoming and supportive environment for women in engineering, fostering confidence in their identity and a sense of belonging.

Course Design and Evaluation

The design of this FYS began with identifying the specific learning outcomes, which are to explain the challenges that women engineer face and to devise strategies to mitigate these challenges. Multiple topics are subsequently selected, including gender stereotypes, invisibility, and chilly climate. Such topics are often overlooked yet tend to be the most challenging obstacles of being a woman in engineering. Industry and academic papers on these topics were identified

and selected as the teaching material of this seminar. Flipped classroom was chosen as the main delivery method to promote students' ownership of the development of their engineering identity. We then formulated the discussion prompts of the identified papers, selected two case studies, and formed a Women in Engineering panel to round up the learning activities for this course. The learning activities were complimented by attending one of the Women+ in Biomedical Engineering (BME) lunches, a faculty-staff-student luncheon series for allyship of women in BME. Table A1 in appendix shows a full version of the course outline. The course design process was completed by identifying assignments of the course with each student writing a 150 to 250-word reflection on each learning activity.

We deployed mixed methods research for assessing the learning outcomes. Participation in our research effort is completely voluntary. Two quantitative surveys, one before and one after the participants have taken our FYS, were given to the participants. Both surveys contained a combination of multiple validated Likert-scale surveys in persistence, self-efficacy, engineering identity, and knowledge of gender equity [6, 11, 12]. The surveys are linked through an anonymous identifier, allowing us to compare the outcomes through paired t-tests. The post-survey also included questions for evaluating the learning activities and teaching effectiveness. To evaluate the reasons and potential ways our FYS has helped the participants, participants were invited for an interview about their experience in this FYS. Anonymized interview transcriptions will be analyzed for common themes reflected in the interviews. Participants who completed both surveys and the interview were compensated with a \$25 gift card. Our IRB has approved this study as an exempt project (#2166817-1).

Results

Eight students enrolled in our pilot offering of this seminar in Spring 2024. Six of eight students majored in an engineering discipline as of the beginning of the quarter. All students enrolled identify as women or non-binary. Three students completed surveys and the interview and are included in the data analysis. Due to the small number of participants, statistical analyses of the quantitative survey were not possible. Therefore, conclusions could not be drawn from the validated portions of the survey.

Table 1. Likert-scale responses (1: strongly disagree; 5: strongly agree) in student self-assessments on effectiveness of this FYS in the post-survey. N=3.

Participating in this FYS prepared me to...	Score /5.00
1. Navigate through difficult situations involving gender equity in engineering.	4.33
2. Develop my confidence as an engineer.	4.33
3. Graduate as an engineering major (including engineering, computer science, and data science).	3.67
4. Work in an engineering-related field after graduation.	4.00
5. Broaden my understanding of diversity, equity, inclusion, and belonging.	4.33
6. Cultivate diversity, equity, and inclusion in engineering.	4.33

However, the post-survey includes self-assessment questions on how well this FYS has prepared them for their professional engineering life. All participants have responded “Neutral” or better in all questions and at least “Agree” or better in questions 1, 2, 5, 6. Responses of the self-assessments can be seen in Table 1. Participants reported their perceptions on the effectiveness of the learning activities in the FYS. The Women in Engineering panel was identified as the most valuable activity, followed by written reflections, case studies, discussion of the papers, and the Women+ in BME lunch.

Discussion

Developing and implementing this first version of the seminar faced significant challenges. Despite strong advertising efforts through college emails, flyers, and social media, enrollment in this first-year seminar was lower than expected. We suspect that the overall lower enrollment of first-year seminars in spring and fewer negative experiences encountered by first-year women engineering students have contributed to the low enrollment we experienced. Enrolled students generally submitted their reflections on time and actively engaged in discussions. The smaller class size contributed to this engagement, fostering a sense of closeness and comfort among the students, although occasional prompting and facilitation was needed to maintain the momentum during the discussion.

Although we could not analyze the validated survey questions to quantitatively determine the achievement level of the learning outcomes due to the low enrollment, student self-assessment of this FYS has so far been positive. The Likert-scale questions in the post survey indicated that students believe that participating in this FYS has benefited them in knowledge, confidence, and ability to navigate through difficult situations. A subjective screening of the interview has corroborated students’ preference in the Women in Engineering panel, especially when the panelists were sharing their own experiences, and the case studies which provided a valuable opportunity for students to engage critically with real-life scenarios encapsulating gender conflicts in the workspace. We will continue to analyze the interview transcriptions to get a better understanding of the central themes of students’ opinions on this FYS.

From the feedback we collected, students expressed their desire for more diverse materials in the seminar. Possible expansion candidates include experiences of non-binary students in engineering, audiovisual materials, and field visits to places such as prototype/manufacturing facilities. Inclusion of non-binary engineers’ experiences and audiovisual materials will make our seminar more inclusive to identities and learning styles, while field visits will serve as hands-on experiences for our students to experience and develop their confidence in engineering.

Based on the feedback, we will incorporate improvements into the next iteration of the course, adding in new course material on negotiation with multiple engineering identities and field trips to engineering labs. Our plans include continuing to offer our seminar in Academic Year 2024-2025 and expanding it into a First-year Learning Community (FLC) in early 2025. The FLC will be led by a faculty member and supported by an undergraduate peer mentor. In the FLC, this seminar will be supplemented by additional community-building events. We will center these events on peer mentoring by pairing students with extra peer mentors in engineering for study sessions. The study sessions are aimed at providing guidance on academic and personal challenges while fostering a strong sense of community.

Acknowledgements

This work is funded by the first-year seminar course support and the Provost's Undergraduate Fellowship at UC Davis. The authors would like to thank the guest panelists Dr. Colleen Bronner and Valerie Quiroz for the Women in Engineering panel.

Appendix

Table A1. Course schedule of the FYS with references to the papers and case studies.

Week #	Discussion topic
1	Introduction and overview of the seminar
2	Case Study: Everyone Knows that Girls Are Bad at Math, Right? [13] – Gendered stereotypes in the society and what the science says; Discussion: A Study on the Status of Women Faculty in Science at MIT [8]
3	Continue the case study from previous week; Discussion: Women in Workplace 2023 Report by McKinsey & Company [10]
4	Discussion: Engineering Education for Women: A Chilly Climate? by Collins et al. [4]
5	Discussion: Engineering identity: Gender and Professional Identity Negotiation among Women Engineers by Hatmaker [7]
6	Case study: Ayesha and the Trade Show [14] – addressing invisibility and “old-boy network” in workplace
7	Continue the case study from the previous week
8	Panel: Women in Engineering
9	No lecture. Students attend Women+ in Biomedical Engineering Lunches
10	Wrap-up

References

- [1] M. J. Johnson and S. D. Sheppard, "Relationships between engineering student and faculty demographics and stakeholders working to affect change," *Journal of Engineering Education*, vol. 93, no. 2, pp. 139-151, 2004.
- [2] G. Lichtenstein, H. L. Chen, K. A. Smith, and T. A. Maldonado, "Retention and persistence of women and minorities along the engineering pathway in the United States," *Cambridge handbook of engineering education research*, pp. 311-334, 2014.
- [3] J. Roy and A. Erdiaw-Kwasie, "Engineering and Engineering Technology by the numbers," in *American Society for Engineering Education, 2022: American Society for Engineering Education*, pp. 1-94.
- [4] D. Collins, A. E. Bayer, and D. A. Hirschfeld, "Engineering Education for Women: A chilly climate?," *Women in Engineering ProActive Network*, 1996.
- [5] B. Bloodhart, M. M. Balgopal, A. M. A. Casper, L. B. Sample McMeeking, and E. V. Fischer, "Outperforming yet undervalued: Undergraduate women in STEM," *PLOS ONE*, vol. 15, no. 6, p. e0234685, 2020, doi: 10.1371/journal.pone.0234685.
- [6] A. Godwin, "The development of a measure of engineering identity," in *ASEE Annual Conference & Exposition*, 2016.
- [7] D. M. Hatmaker, "Engineering identity: Gender and professional identity negotiation among women engineers," *Gender, Work & Organization*, vol. 20, no. 4, pp. 382-396, 2013.
- [8] N. Hopkins, "A study on the status of women faculty in science at MIT," in *AIP Conference Proceedings*, 2002, vol. 628, no. 1: American Institute of Physics, pp. 103-106.
- [9] B. E. Hughes, W. J. Schell, E. Annand, R. Beigel, M. B. Kwapisz, and B. Tallman, "Do I think I'm an engineer? Understanding the impact of engineering identity on retention," in *American Society for Engineering Education*, 2019.
- [10] E. Field, A. Krivkovich, S. Kügele, N. Robinson, and L. Yee, "Women in the Workplace 2023," McKinsey & Company, 2023. [Online]. Available: <https://www.mckinsey.com/featured-insights/diversity-and-inclusion/women-in-the-workplace>
- [11] N. A. Mamaril, E. L. Usher, C. R. Li, D. R. Economy, and M. S. Kennedy, "Measuring undergraduate students' engineering self-efficacy: A validation study," *Journal of Engineering Education*, vol. 105, no. 2, pp. 366-395, 2016.
- [12] S. A. Shields, M. J. Zawadzki, and R. N. Johnson, "The impact of the Workshop Activity for Gender Equity Simulation in the Academy (WAGES–Academic) in demonstrating cumulative effects of gender bias," *Journal of Diversity in Higher Education*, vol. 4, no. 2, p. 120, 2011.
- [13] M. Leonard, "Everyone Knows Girls Are Bad at Math, Right?!," *National Science Teaching Association*.
- [14] G. Bett, L. Folks, and N. Schiller, "Ayesha and the Trade Show," *The NAVIGATE Project: A Case-Study Approach to Overcoming Barriers to Advancement for Women in STEM*.