Evaluating the Impact of Teaching Undergraduate Engineering Students Strategies to Become Leaders in Diverse Environments

Dr. Renee M. Desing, University of Washington

Dr. Renee Desing is an Assistant Teaching Professor in the Department of Mechanical Engineering at the University of Washington. Her research interests include diversity, equity, and inclusion in the engineering classrooms and workplaces. Dr. Desing graduated from Ohio State with her Ph.D. in Engineering Education, and also holds a B.S. in Industrial Engineering from the Georgia Institute of Technology and a M.S. in Industrial Engineering and Operations Research from the Pennsylvania State University.

Ms. Cathryne Jordan, University of Washington

Cathryne, UW College of Engineering, Assistant Director, Office of Inclusive Excellence, Gender Equity and Student Groups. Directing and working with the educational K-20 community, university, public and/or private sector outreach an

Arron Corey Clay, University of Washington
Dr. Joyce Yen, University of Washington
Ali Cho, University of Washington
Robin Neal Clayton, University of Washington
Karen Thomas-Brown, University of Washington

Evaluating the Impact of Teaching Undergraduate Engineering Students Strategies to Become Leaders in Diverse Environments: A Work in Progress

Introduction

Historically, engineering education has focused on technical skill development [1], where non-technical skills such as teamwork, communication, leadership, and social responsibility have been emphasized only recently to ensure engineers are being educated holistically [2]. Furthermore, while historically marginalized groups remain underrepresented in engineering, the field is starting to see growth in diversity [3]. Aligned with this newer focus on preparing holistic engineers for a professional engineering environment and the growth of diversity within the field, ABET updated their student outcomes in 2019 to include an outcome specifically dedicated to effectively working with teams to create collaborative and inclusive environments [4], [5], [6]. Additionally, one of the top anticipated trends for organizations in 2024 is to shift to integrating and embedding diversity, equity, and inclusion (DEI) throughout their business objectives, daily operations, and culture [7], which necessitates inclusive leadership skills. However, only 5% of leaders globally are considered to be skilled inclusive leaders [8].

In support of the changing landscape within the engineering field and engineering education, we aim to bring DEI leadership to the forefront of engineering education through our diversity engineering leadership course, titled *Leadership Development to Promote Equity in Engineering Relationships*. Engineering educators must explicitly teach inclusive leadership skills to meet the pedagogical advancements in engineering education and to modernize course content per current engineering, organizational, and societal issues and needs.

Background

Our diversity leadership course, first implemented in 2009, was the product of a first-round, Innovation through Institutional Integration (I3) NSF grant. The course was created to increase the participation of underrepresented undergraduate students in the College of Engineering by improving the climate for women, minorities, and people with disabilities in engineering. The learning objective of our course is for engineering students to acquire leadership skills and implement behaviors that create a more supportive and inclusive engineering environment. Students explore topics such as diversity in engineering, the impact of implicit and systemic bias, how to create inclusive cultures, community engagement, and leadership in diverse engineering environments. The course enlists engineering students' energy, creativity, social conscience, and on-the-ground perspectives in improving the diversity environment. We engage students through various active learning techniques to allow them to practice leadership skills (such as how to be an ally), engage in diverse teams through exploring their peers' perspectives, and develop a sense of belonging in a safe, inclusive learning environment.

While the grant ended in 2013, the College of Engineering has continued to invest in the course, increasing the course offering from once a year to once a quarter and expanding the courseload from one credit to three credits. Furthermore, the course now satisfies the university-wide diversity course requirement. Since 2009, over 300 students have taken the course, with enrollment averaging about 30 students per academic quarter.

Purpose

We aim to continually redesign and transform the course to incorporate recent societal issues (e.g., post-COVID, the Black Lives Matter movement) and their impact on DEI in engineering education, address topics of interest to current students, and utilize up-to-date engineering education pedagogical best practices. Previously, we conducted a program evaluation at the end of the grant in 2013 and issued a 10-year anniversary retrospective survey to former students in 2019 to inquire about the value of the course for their academic and professional careers. Now, we are embarking on a project to formally evaluate the course content and its direct impact on current students, particularly their leadership skills with regards to DEI in engineering, to inform our next course redesign process. As part of the long-term goals for our project, we want to evaluate the impact the redesigned course has on students' leadership development, both in their remaining academic careers and their future professional careers.

This work-in-progress practice paper presents the preliminary results of the first phase of our current project. In this first phase, we evaluate the course's effectiveness in achieving its learning outcomes and its impact on current students' inclusive leadership skills. We also aim to assess how we can improve the course based on this evaluation.

Conceptual Framework

To guide our course learning objectives, evaluation, and pedagogical changes, we are using social justice education [9], engineering for social justice [10], and situated engineering learning [11]. Social justice education [9] defines seven course concepts for their social justice education approach, including the pervasiveness of systems of oppression, individual and group identities in the context of socially constructed categories and positionalities of privilege and disadvantage, and the importance of critical awareness, knowledge, and skills to challenge, resist, and take effective action for change. Our goal is to move the course from a diversity approach to a social justice approach. Engineering for social justice [10] promotes the responsibility of engineering to solve problems at the intersection of social and technical issues, foster inclusive excellence, and make engineering socially relevant. Through this framework, we seek to evaluate the impact of the course on students' leadership development with respect to diversity, equity, inclusion, and justice. Situated engineering learning [11] considers how social and material context, activities and interactions, and participation and identity impact the learning process for engineers. We use this framework to support our course design, pedagogy, and student engagement, particularly from an active, collaborative learning perspective. Together, these three frameworks offer concrete pedagogical changes to support the inclusive leadership education of engineers.

Methods

To assess the effectiveness of our diversity leadership course, we administered pre- and post-course surveys to students enrolled in our course in Autumn 2022, Winter 2023, and Spring 2023. The surveys included both quantitative and qualitative questions. The pre-course survey included questions to assess why students are taking their course, what they already know about the topics that will be taught in the course, their expectations for what they will learn in the course, and how they see the course enhancing their leadership skills in DEI. The post-course survey asked students whether their expectations were met and their plans to use what they learned in the future, such as applying leadership skills.

We performed quantitative and qualitative analysis on the data collected. For the Likert-style questions, we conducted descriptive statistics and t-tests using Microsoft Excel to evaluate trends and their significance between the pre- and post-course surveys. For open-ended questions, we themed the data to organize, categorize, and gain a deeper understanding of students' experiences with the course in relation to the learning outcomes [12]. Specifically, we grouped responses into themes on the pre- and post-course survey responses separately using Taguette, quantitized each of the themes by the number of responses coded to provide insight into the magnitude of students' expectations and prior knowledge, and compared the similarities and differences in the themes and their frequency between the pre- and post-course surveys. Examining the quantitative and qualitative results together, we aimed to assess whether the course objectives and learning outcomes were achieved and identify gaps between what students were expecting to learn and what is currently covered in the course.

Limitations

We did not track respondents' identities, so we could not conduct any paired comparisons between the pre- and post-course surveys by individual students; nor did we request demographics on the post-course survey. However, we have rectified these limitations for the surveys collected for the 2023-2024 academic year. We also observed lower responses rates for the post-course survey (see Table 1). It was difficult for students to complete both our survey and the university-wide evaluations of instruction at the end of the quarter. We have also mitigated these limitations starting in the 2023-2024 academic year by giving students time in class to take the survey and offering course credit to incentivize students to take the survey.

Preliminary Results

We received 96 responses for the pre-course survey and 28 responses for the post-course survey across the three quarters of the 2022-2023 academic year (see Table 1). Total course enrollment during these quarters was 106, resulting in a 91% response rate for the pre-course surveys and a 26% response rate for the post-course surveys.

Table 1: Enrollment and Survey Responses by Quarter

Quarter	Enrollment	# Responses (Pre)	Response Rate (Pre)	# Responses (Post)	Response Rate (Post)
Autumn 2022	47	41	87%	7	15%
Winter 2023	30	28	93%	12	40%
Spring 2023	29	27	93%	9	31%
Total	**106**	**96**	**91%**	**28**	**26%**

Of the pre-survey respondents, three-quarters indicated either Asian (41%) or White (33%) as their race/ethnicity (Table 2), while the gender preference was 59% men and 33% women (Table 3). While these numbers for both race/ethnicity and gender are aligned with the distribution of the College of Engineering enrollment at our university [13], they highlight the continued structural issue of lack of representation of Black, Latinx, and women students in engineering [3].

Table 3: Race/Ethnicity of Pre-Course Survey Respondents by Quarter

Race/Ethnicity	Autumn 2022	Winter 2023	Spring 2023	Total (%)
Asian	18	11	10	39 (41%)
Black/African American	3	1	2	6 (6%)
Hispanic/Latinx	2	1	1	4 (4%)
White	11	11	10	32 (33%)
Two or More	3	1	3	7 (7%)
Not Indicated	4	3	1	8 (8%)
Total	**41**	**28**	**27**	**96**

Table 2: Gender Preference of Pre-Course Survey Respondents by Quarter

Gender Preference	Autumn 2022	Winter 2023	Spring 2023	Total (%)
Man	25	16	16	57 (59%)
Woman	13	9	10	32 (33%)
Non-Binary	1	0	0	1 (1%)
Not Indicated	2	3	1	6 (6%)
Total	**41**	**28**	**27**	**96**

Quantitative Results

Our quantitative analysis focused on four survey questions asked on both the pre- and post-course surveys to evaluate change in students' learning (Table 4). The survey items were 5-point Likert-style questions, where 5 was "strongly agree" and 1 was "strongly disagree." T-tests performed on the four survey items indicated all were statistically significant ($p < 0.05$).

Table 4: T-Test Results (indicates statistically significant at $p < 0.05$)*

Survey Item (modified wording for post-course survey in parentheses)	Mean, Pre	Mean, Post	p-value
This course will help (helped) me to appreciate diversity at UW and in my daily life.	4.375	4.714	0.003*
Taking the course will help (has helped) me learn how to be open and comfortable with people who are different than me.	3.844	4.393	0.021*
I believe I will be (I have been) exposed to many diverse culture, opinions, and values in this class.	3.865	4.393	0.029*
How important to you is having a community of engineering students across different disciplines?	3.833	4.231	0.012*

Because these four questions align with the learning outcomes for the course, it is encouraging to see significant increases in scores from the pre-course survey to the post-course survey for each of these four questions. These results suggest the course is highlighting the importance of diversity, teaching students to be open to different perspectives and comfortable in a diverse environment, exposing students to diverse cultures and opinions, and building an interdisciplinary community across engineering disciplines.

Qualitative Findings

The qualitative questions that we have thematically analyzed and compared across the pre- and post-course surveys asked students about their expectations for the course and whether their expectations were met. When we asked students on the pre-course survey, "*What are the top three things you expect to learn from this course?*", we received a list of 255 expectations across the 96 responses, for an average of 2.66 expectations per student. The thematic coding resulted in 5 themes, which are shown in Table 5 along with the number of and example responses. Quantitizing the themes provided insight into the expected topics for the course, so that we can consider how to modify course content to meet students' needs and address knowledge gaps.

Table 5: Expectations Themes, Counts, and Example Responses from the Pre-Course Survey

Theme	Count	Example Responses
1. Learning about the state of DEI in engineering	85	• *"Inequity in the field of engineering-specifically how it affects women, POC, and those with disabilities"* • *"What equity means in an engineering setting"* • *"Learn the benefits of having diversity in [the] workforce"*
2. Learning leadership and professional skills as they relate to DEI	63	• *"Learning how to do project management with a diverse group of people in different education, backgrounds, and specialties"* • *"How to be a strong leader to diverse groups of people"* • *"How to develop diversity-oriented leadership skills"*
3. Learning strategies and skills to be more diverse, inclusive, and equitable	61	• *"How to encourage others and spread awareness regarding DEI issues"* • *"What I can do to create a more equitable environment"* • *"How to dismantle systematic issues within engineering"*
4. Learning about others' perspectives and identities	24	• *"I expect to learn about perspectives other than my own, as well as how to better respect and appreciate those perspectives"*
5. Learning about their own perspectives and biases	11	• *"How to identify my personal biases"*
6. Other	7	• "*I don't really have many expectations"*
Total	**255**	

The first (and most common) expectation of students with 85 responses was *Learning about the state of DEI in engineering*. This theme included responses related to learning about the connection between DEI and engineering, challenges and inequities, reasons for lack of diversity, who is marginalized in engineering, and the benefits of diversity. The second theme*, Learning leadership and professional skills as they relate to DEI*, with 63 responses, shows students' curiosities around learning leadership, communications, project management, collaboration, and other skills that will allow them to succeed as professionals in a diverse workplace. For the third theme, *Learning how to be more diverse, inclusive, and equitable*, with 61 responses, students were interested in learning about actionable skills or strategies they could use to improve DEI in engineering. For example, students were expecting to learn how to create inclusive environments, identify and address inequities and biases, and spread awareness of DEI issues. The last two themes were two sides to a coin, centering on *Learning about others' perspectives and identities* and *Learning about their own perspectives and biases* (with 24 and 11 responses, respectively). Students were interested in learning about the experiences of their peers, particularly those that are minoritized, and how to take those perspectives into account, as well as learning how to identify their own implicit biases and broaden their own thinking.

When comparing the expectations students had in the pre-survey to the results we received when we asked, "*Were your expectations met for this course?",* we found that most students (26 of 28 responses) indicated that their expectations were met. While most responses did not elaborate beyond stating "yes," one response that will help us make future adjustments to the course was, "*There was less leadership focus but it definitely met my expectations for discussing and learning about unequal barriers in engineering and some ways to address them*."

Next Steps

Our next steps include additional analysis of the current survey data, such as ANOVAs to identify trends between groups (e.g., gender, race/ethnicity, major, year in school), and deeper qualitative analysis on the written responses to better understand students' expectations specifically regarding leadership skills, experiences in the class, and whether they are actively engaging with the course content. We are also collecting additional survey data for the 2023-2024 academic year and will incorporate that data into our analysis as well, and plan to conduct in-depth interviews with current and former students to garner detailed feedback on the utility of the course content. While the data collection and analysis continue, our preliminary results suggest potential modifications to the course's pedagogy, such as a greater emphasis on tangible leadership skills, and underscore positive changes in students' perception of diversity and leadership. However, deeper exploration is required to grasp the course's complete impact, with a focus on real-world applications and challenges beyond students' expectations. We look forward to further insights from our continued evaluation and assessment of the students' feedback and how to continue to transform the course to meet their and the engineering field's needs for inclusive leadership development.

References

[1] B. E. Seely, "The other re-engineering of engineering education, 1900–1965," *J. Eng. Educ.*, vol. 88, no. 3, pp. 285–294, 1999, doi: 10.1002/j.2168-9830.1999.tb00449.x.

[2] E. De Graaff and W. Ravesteijn, "Training complete engineers: Global enterprise and engineering education," *Eur. J. Eng. Educ.*, vol. 26, no. 4, pp. 419–427, Dec. 2001, doi: 10.1080/03043790110068701.

[3] American Society for Engineering Education, "Engineering and Engineering Technology: By the Numbers," 2022. Accessed: Feb. 05, 2024. [Online]. Available: https://ira.asee.org/wp-content/uploads/2023/12/Engineering-and-Engineering-Technology-by-the-Numbers-2022-1.pdf

[4] ABET Engineering Accreditation Commission, "Criteria for Accrediting Engineering Programs," ABET, Baltimore, MD, 2018.

[5] ABET, "FAQs for EAC C3 & C5 Criteria Changes," ABET, Apr. 2019. Accessed: Feb. 05, 2024. [Online]. Available: https://www.abet.org/wp-content/uploads/2019/04/FAQs-for-EAC-C3-C5-4-8-2019.pdf

[6] A. Karimi and R. Manteufel, "Most Recent Updates to ABET-EAC-Criteria 3, 4 and 5," 2020.

[7] E. R. McRae, P. Aykens, K. Lowmaster, and J. Shepp, "9 Trends That Will Shape Work in 2024 and Beyond," *Harvard Business Review*, Jan. 23, 2024. [Online]. Available: https://hbr.org/2024/01/9-trends-that-will-shape-work-in-2024-and-beyond

[8] Korn Ferry, "The Benefits of Inclusive Leadership," *Korn Ferry Insights*. [Online]. Available: https://www.kornferry.com/insights/featured-topics/diversity-equity-inclusion/the-benefits-of-inclusive-leadership

[9] M. Adams and X. Zúñiga, "Getting Started: Core Concepts for Social Justice Education," in *Teaching for diversity and social justice*, 3rd ed., M. Adams and L. A. Bell, Eds., New York, NY: Routledge, 2016.

[10] J. A. Leydens and J. C. Lucena, *Engineering Justice: Transforming Engineering Education and Practice*. in IEEE PCS Professional Engineering Communication Series. IEEE Press, 2018.

[11] A. Johri and B. M. Olds, “Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences,” *J. Eng. Educ.*, vol. 100, no. 1, pp. 151–185, 2011, doi: 10.1002/j.2168-9830.2011.tb00007.x.
[12] J. Saldaña, *The Coding Manual for Qualitative Researchers*, 2nd ed. Thousand Oaks, CA: SAGE Publications, 2013.
[13] University of Washington College of Engineering, “About us.” Accessed: Feb. 02, 2024. [Online]. Available: https://www.engr.washington.edu/about