Cultivating Empathy in Engineering Education: Pedagogical Pathways Toward Inclusive Practice

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WIP: Cultivating Empathy in Engineering Education: Pedagogical Pathways Toward Inclusive Practice

Abstract: As engineering increasingly intersects with societal and global challenges, empathy has become an essential dimension of professional competence, enabling engineers to understand diverse human needs, collaborate across cultures, and design with social responsibility in mind. Engineering programs worldwide recognize the need to foster culturally responsive, inclusive, and socially conscious professionals, the systematic integration and assessment of empathy within engineering curricula remain underdeveloped, particularly in relation to cultural and international dimensions of learning. This work-in-progress (WIP) study examines how undergraduate engineering programs are incorporating empathy into coursework, the pedagogical strategies employed to foster empathetic engagement, and the methods used to assess empathy-related learning outcomes within culturally diverse educational contexts. Using a mixed-methods approach, the study analyzes curricular artifacts, student-generated work, and faculty perspectives across multiple institutions, including U.S.-based universities serving nationally and culturally diverse student populations and programs with explicit global or international engineering emphases. Using a mixed-methods approach, the study analyzes curricular artifacts, student-generated work, and faculty perspectives across multiple institutions, including U.S.-based universities serving nationally and culturally diverse student populations and programs with explicit global or international engineering emphases. Pedagogical approaches such as community-engaged learning, human-centered design, interdisciplinary collaboration, and reflective practice are examined for their role in supporting empathy development across cultural boundaries. The findings aim to advance understanding of how empathetic practices enhance students' cultural perspectives, promote inclusivity, and prepare future engineers to exemplify compassion-driven and socially responsive engineering practices.

Introduction

As engineering practice increasingly confronts complex societal and global challenges, the profession demands more than technical proficiency. Engineers are now expected to design solutions that are socially responsive, ethically grounded, and attentive to the diverse human experiences embedded within the systems they create. In this context, empathy, defined as the capacity to recognize, understand, and engage with the perspectives, emotions, and needs of others, has emerged as a critical dimension of contemporary engineering competence. Prior research [1-3] demonstrates that empathy underpins effective communication, cross-cultural collaboration, ethical decision making, and stakeholder engagement, ultimately contributing towards responsible and human centered engineering outcomes.

Despite its growing recognition, empathy remains an insufficiently theorized and implemented construct within engineering education. Existing research suggests that while educators increasingly acknowledge empathy as valuable, its curricular integration, pedagogical enactment and assessment vary across institutions and cultural contexts. This gap is especially consequential as engineering graduates increasingly work in multicultural teams, engage with communities across national boundaries, and address challenges that disproportionately affect marginalized populations. Empathy across cultural, national, and social differences has been

shown to be more difficult to develop and sustain, underscoring the need for intentional pedagogical design and assessment strategies within engineering curricula.

In response, engineering programs have begun to explore pedagogical approaches aimed at cultivating empathy, including community engaged learning, human centered and empathic design frameworks, interdisciplinary collaboration and reflective practices. These strategies seek to create learning environments in which students can interact meaningfully with diverse stakeholders and critically reflect on the social, cultural, and ethical dimensions of engineering practice. While such approaches show promise, empirical evidence regarding their effectiveness, implementation, and assessment remains limited. Addressing this gap, the present WIP study investigates how empathy is conceptualized, taught, and evaluated within undergraduate engineering programs, while focusing on cultural and pedagogical strategies used to develop empathetic mindsets amongst future engineers.

Background

Empathy has increasingly been recognized as a critical competency in engineering practice [4], particularly as engineers are called upon to address complex societal challenges involving diverse stakeholders. Within engineering contexts, empathy is often conceptualized as a multidimensional construct encompassing cognitive perspective-taking, affective understanding. and the ability to translate stakeholder needs into informed and ethical design decisions. Empathic engagement enables engineers to reduce blind spots in design, improve communication and support more inclusive and socially responsible engineering outcomes that more effectively address human needs. In design education literature, empathy is frequently positioned as a foundational to human-centered design [5 -7] and as a key attribute of globally competent engineers. Through empathic engagement, engineers are better equipped to incorporate ethical, cultural, and social considerations into technical problem solving.

Community-based and participatory learning experiences have emerged as one of the most effective pedagogical pathways for fostering empathy in engineering students. Through sustained engagement with community partners, who are often from cultural, national or socioeconomic backgrounds different from their own, students gain insight into lived experiences, values and constraints that extend beyond purely technical considerations [8]. Research demonstrates that participatory design and co-creation activities enhance students' understanding of social context, ethical responsibility and cultural sensitivity, which are essential for engineering practice in international and multicultural settings.

Human-centered and empathic design frameworks further support the development by emphasizing iterative engagement with users through interviews, observations, empathy mapping and stakeholder analysis. These practices [9] encourage students to challenge assumptions, recognize cultural differences, and incorporate diverse perspectives into technical decision making. Students engaged in empathic design activities have been shown to develop more nuanced understandings of user needs and greater intentionality in addressing ethical and cultural implications of design choices. These frameworks encourage engineers in training to view empathy not as an abstract ideal, but as an actionable design practice that informs technical choices and system performance.

Interdisciplinary collaboration [1] also plays a significant role in cultivating empathy within engineering education. Learning environments that bring together students from different disciplines, identities, and cultural backgrounds require negotiation of diverse worldviews and problem-solving approaches, thereby fostering perspective-taking and relational skills. Reflective and metacognitive practices are widely recognized as powerful mechanisms for empathy development [10]. Practices including reflective writing, structured dialogue, and journaling further support empathy development by enabling students to examine personal assumptions, biases, and positionality in relation to engineering work. Empathy development is frequently linked in literature to ethical reasoning and sustainability-oriented thinking, suggesting that reflection plays a key role in shaping engineers' professional identities and sense of responsibility.

Challenges in Integrating Empathy into Engineering Curricula

Despite the promise of these pedagogical approaches, engineering programs face significant challenges in embedding empathy within engineering curricula. A major challenge is the lack of consensus regarding how empathy should be defined and assessed in engineering contexts, particularly across cultural and institutional boundaries. Faculty experience setbacks in balancing traditional expectations of technical rigor with affective learning objectives within already crowded curricula. Faculty perspectives vary widely, with some instructors expressing uncertainty or discomfort in teaching socially oriented competencies. Additional challenges identified in the literature include limited faculty preparation, difficulty scaling community-engaged experiences, and institutional constraints related to time, resources and adaption of traditional assessment techniques. These challenges highlight the need for systematic, methodologically rigorous research that examines how empathy is intentionally integrated, conceptualized, taught, and evaluated across diverse engineering programs.

Research Design and Outcomes

This study employs mixed methods design to examine how undergraduate engineering education embeds empathy into their curricula and assesses the development of empathic mindsets among students. The study includes participation from three undergraduate engineering institutions: two US based universities serving culturally and nationally diverse student populations and one institution with a strong global or international engineering emphasis. Institutions were selected using purposeful sampling based on the presence of design-focused, community-engaged, ethics-oriented, or global engineering coursework. Multiple data sources are used to develop a holistic view of empathy integration across engineering programs as shown in Figure 1.

Data collection involves three primary sources. First, approximately 25-30 curricular artifacts are collected from 8-10 undergraduate engineering courses, including course syllabi, learning outcomes, assignment prompts, and assessment rubrics. These artifacts are analyzed using qualitative content analysis to examine how empathy is defined, whether it is explicitly

articulated as a learning outcome, and how it is aligned with instructional activities and assessment practices.

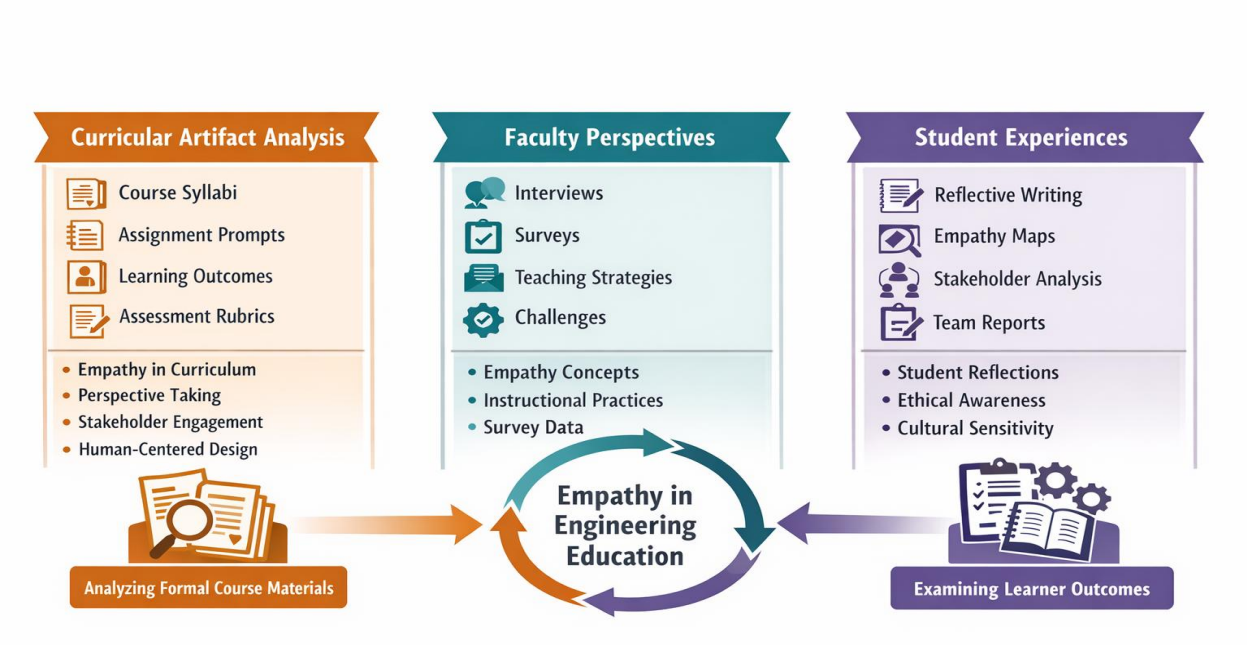

Figure 1. Study Methodology

Second, student-generated artifacts are collected from an estimated 120-150 undergraduate engineering students enrolled in the participating courses. Artifacts include reflective writing, design reports, empathy maps, stakeholder analyses, and team process documentation. These materials are analyzed using a deductive–inductive coding framework informed by empathy and human-centered design literature, with attention to evidence of perspective-taking, cultural awareness, ethical reasoning, and responsiveness to stakeholder needs. Inter-rater reliability procedures are employed to ensure consistency in qualitative analysis.

Third, faculty perspectives are gathered through semi-structured interviews from approximately 10-12 faculty members and surveys from approximately 20-25 instructors. Faculty data examine how empathy is conceptualized within engineering contexts, pedagogical strategies used to foster empathic engagement, perceived challenges, and beliefs about the role of empathy in professional engineering practice. Aggregate demographic data related to national and cultural background and prior international experiences are collected for both students and faculty to explore how cultural diversity intersects with empathy development, independent of institutional location.

Quantitative survey data are analyzed using descriptive statistics, while qualitative data from interviews and artifacts are analyzed thematically. Triangulation across data sources strengthens validity and provides a comprehensive understanding of empathy integration across culturally diverse engineering learning environments. Data collection and analysis are currently underway,

and full empirical results will be reported in the March revision. These findings will be shared with reviewers and the broader engineering education community to inform future efforts to intentionally embed empathy within engineering curricula, develop meaningful assessment strategies, and align empathy related learning outcomes with accreditation expectations and inclusive engineering practice.

Conclusion

Empathy is an essential dimension of contemporary engineering competence, particularly as engineers are expected to work across cultural boundaries and contribute design solutions that are socially responsive, ethically grounded, and inclusive of diverse human experiences. This WIP study advances understanding of how empathy is intentionally integrated and assessed within undergraduate engineering curricula by examining pedagogical practices across culturally diverse and internalized learning contexts. By emphasizing community-engaged learning, human centered design, interdisciplinary collaboration, and reflective practice, this work affirms that empathy is not ancillary to technical rigor but foundational to inclusive, ethical and globally responsive engineering education. The forthcoming empirical findings will inform future curricular design, assessment strategies and international engineering education initiatives aimed at preparing engineers to responsibly engage with diverse communities worldwide.

References:

[1] Gundagatti, S., Baligar, P., Talageri, V., Amashi, R. (2025). Empathy in Engineering Education: A Bibliometric Study. In: Mishra, S., Kothiyal, A., Iyer, S., Sahasrabudhe, S., Lingnau, A., Kuo, R. (eds) Proceedings of the International Conference on Technology 4 Education 2024, Volume 2. T4E 2024. Lecture Notes in Educational Technology. Springer, Singapore.
[2] Afroogh, S., Esmalian, A., Donaldson, J. P., & Mostafavi, A. (2021). Empathic design in engineering education and practice: an approach for achieving inclusive and effective community resilience. Sustainability, 13(7), 4060.
[3] Brewer, M. A., Sochacka, N. W., Walther, J., & Miller, S. E. (2017, July). How do students meaningfully interpret the role of empathy in engineering? A social phenomenological study. In Proceedings of the 2017 Research in Engineering Education Symposium, Bogota, Colombia (pp. 6-8).
[4] A. Surma-aho, C. Chen, K. Hölttä-Otto, and M. Yang, “Antecedents and Outcomes of Designer Empathy: A Retrospective Interview Study,” in Volume 7: 31st International Conference on Design Theory and Methodology, Anaheim, California, USA: American Society of Mechanical Engineers, Aug. 2019, p. V007T06A033. doi: 10.1115/DETC2019-97483.
[5] McGinley, C., and Dong, H., 2011, "Designing with information and empathy: Delivering human information to designers," The Design Journal, 14(2), pp. 187-206.
[6] Fila, N. D., & Hess, J. L. (2016, June). In their shoes: Student perspectives on the connection between empathy and engineering. In 2016 ASEE Annual Conference & Exposition. New Orleans, Louisiana. 10.18260/p.26120

[7] Hauke, E., Cresswell-Maynard, K., & Craddock, D. (2015). An interdisciplinary approach to embedding the global dimension into engineering design: empathy, engagement and creativity. In DS 82: Proceedings of the 17th International Conference on Engineering and Product Design Education (E&PDE15), Great Expectations: Design Teaching, Research & Enterprise, Loughborough, UK, 03- 04.09. 2015 (pp. 087-092).
[8] A. Albers, N. Bursac, J. Heimicke, B Walter and N. Reiß, 20 years of co-creation using case based learning – an integrated approach for teaching innovation and research in Product Gerneration Engineering, 20th International Conference on Interactive Collaborative Learning, ICL2017, 29–27 September 2017, Budapest, Hungary, pp. 1014–1025, 2017
[9] J. L. Hess, N. D. Fila, C. T. Schimpf, A. Godwin, and E. A. Sanders, "A Research Study on Assessing Empathic Formation in Engineering Design," ASEE 2023.
[10] Hess, J. L., & Fila, N. D. (2016, June), *The Development and Growth of Empathy Among Engineering Students* Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.26120