IUSE: Cultivating engineering students' empathy at a Primary Undergraduate Institution

Hengtao Tang, University of South Carolina

Hengtao Tang is an associate professor of Learning Design and Technologies at the University of South Carolina. His research interests address the intersection of self-regulated learning, multimodal data analytics, and artificial intelligence (AI) in education. Specifically, Hengtao applies multimodal data analytics to understand how learners regulate their learning and their collaborative problem solving in technology-enhanced learning environments and thereby creates AI-driven scaffolds to facilitate learner outcomes toward STEM careers.

Yingxiao Qian, University of South Carolina

Dr. Yingxiao Qian is a clinical assistant professor in Learning Design and Technologies at the University of South Carolina. Her research interest is to design and develop various learning environments that utilize technology to enhance K-12 students' real-world problem-solving abilities in STEM education contexts.

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Abstract

To date, there has been a growing need to foster engineering students' empathy in addition to their technical competence. However, traditional engineering curricula offer limited opportunities for students to engage with human-centered aspects of problem solving, particularly at Primary Undergraduate Institutions (PUIs). This study explored the integration of design thinking into an undergraduate robotics course at a PUI to develop engineering students' empathy. A convergent mixed methods design was employed, with quantitative and qualitative data collected to examine the impact of design thinking activities on engineering students' development of empathy. Quantitative results indicated a statistically significant increase in students' empathy following the intervention, while qualitative findings further suggested that students developed greater awareness of stakeholder perspectives and a deeper appreciation for the ethical and societal implications of engineering design in a human-centered perspective. These findings demonstrated that embedding design thinking into technology-focused engineering curriculum showed benefits of developing students' empathy. Practical implications for engineering educators seeking to promote human-centered and socially responsible engineering practice are offered.

Introduction

Engineering education has increasingly viewed empathy as an integral professional competency for future engineers [1], [2], given its role in human-centered design and ethical decision-making [3], [4], [5]. Empathy is defined as a capacity that allows one to meaningfully engage with the perspectives of others [6]. However, traditional engineering curricula often prioritize analytical or programming competencies while offering limited opportunities for students to develop their empathy skills [7], [8], particularly at Primary Undergraduate Institutions (PUIs). While students at PUIs often benefit from smaller class sizes and hands-on learning experiences, they may have fewer opportunities to engage with large-scale industry practices [9], [10].

Design thinking, as an iterative and human-centered problem-solving framework [7], [11], can provide a structured approach for engaging engineering students in human-centered problem solving. Specifically, students are allowed to understand stakeholder perspectives, define meaningful problems, and develop prototypes of their proposed solutions that account for real-world constraints [8], [12]. This study thus examined how integrating design thinking into an undergraduate engineering course impacted the development of empathy among engineering students at a PUI.

Methodology

The study employed a convergent mixed methods design [13] to investigate the impact of design thinking on engineering students' empathy at a PUI in the southeastern United States. Quantitative and qualitative data were collected concurrently, analyzed independently, and integrated during the interpretation of findings to provide a comprehensive understanding of the intervention's impact.

A total of 20 undergraduate engineering students (ages 19-21) enrolled in a required robotics coding course voluntarily participated in this study. Most of the participants were male students and identified themselves as White/Caucasian. All of them had no prior experience of engaging in design thinking activities. The course was redesigned to embed design thinking in order to engage participants in authentic, industry-aligned engineering challenges. Through interacting with professional liaisons, participants were introduced to real-world problems requiring consideration of safety, usability, and societal impact. Working in teams, participants progressed through iterative stages of empathy building, problem identification, ideation, prototyping, and evaluation. Throughout this process, participants were encouraged to consider multiple stakeholder perspectives and reflect on the broader implications of their design decisions.

For quantitative data, participants' empathy was assessed using Interpersonal Reactivity Index [23], capturing dimensions related to perspective-taking and empathic concern. A Wilcoxon signed rank test was conducted to compare the change in participants' empathy before and after attending the redesigned course. For qualitative data, participants' experience within this course were inquired through semi-structured interviews [24]. Specifically, eight participants were purposively selected to share their experience. Each interview was audio-recorded upon participant's consent and then transcribed for subsequent analysis.

Findings

Quantitative findings revealed a statistically significant increase in participants' empathy following the experience of design thinking activities, suggesting that structured engagement in human-centered design processes positively influenced how students approach engineering problems. Complementary qualitative findings provided further insight into this change in participants' empathy, highlighting shifts in their awareness of stakeholder needs, recognition of ethical considerations, and ability to connect technical decisions with real-world consequences.

Implications

The findings underscore the potential of design thinking as an effective pedagogical approach for cultivating empathy within engineering education at PUIs. By embedding human-centered practices into technically rigorous courses, educators can create learning environments that promote cognitive development and professional skill. This approach aligns with broader calls for engineering education reform that emphasize the integration of ethical reasoning, social awareness, and interdisciplinary thinking.

Despite its contributions, the study is limited by its single-institution setting and relatively small sample size, which may constrain the generalizability of the findings. Future research could extend this work by examining longitudinal impacts of empathy-focused interventions and exploring their applicability across diverse institutional contexts and engineering disciplines.

In conclusion, this study demonstrates that incorporating design thinking into undergraduate engineering courses can meaningfully enhance students' capacity to engage with the human dimensions of engineering problems. For PUIs in particular, such approaches offer a promising pathway for preparing students to navigate complex professional environments while contributing to socially responsible innovation.

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