

A Mixed Methods Exploration of Ethics and Equity in Early-Career Engineering Practice

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Her work explores how early-career engineers navigate ethical challenges, equity issues and artificial intelligence (AI) as they transition from academia into professional practice. She employs both qualitative and quantitative research methods to investigate professional development, workforce preparation, and the broader goal of broadening participation in engineering.

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Abstract

This research brief shares findings from the first two phases and plans for the third phase of our research design, which explores how early-career engineers experience and navigate ethics and equity challenges as they transition from academic training into professional practice. Engineering education holds an important role in preparing future engineers not only as technical experts but also as ethical, socially responsible professionals. However, despite ongoing reforms, current ethics instruction often fails to translate into practical competence or confidence in real-world decision-making. Our study addresses that gap by exploring how early-career engineers experience and navigate ethics and equity challenges during their transition from academic training to professional practice by employing a three-phase sequential exploratory mixed methods design: an initial qualitative phase (qual), followed by a quantitative survey phase (QUAN), and concluding with a second qualitative phase (QUAL). This research highlights the need for stronger integration of experiential ethics and equity education within engineering curricula and workplace training to better prepare engineers for complex professional challenges. The implication of this research involves the urgent need for engineering education to go beyond awareness and incorporate applied, discussion-based ethics pedagogy rooted in lived experience, such as those of which our study provides.

Keywords: mixed methods research; engineering ethics; equity; early-career engineers; engineering practice

Introduction

Engineering as a profession holds profound responsibilities to protect public welfare and advance societal good. These responsibilities are often described as the ethical obligations of engineers. For the purposes of this study, ethics refers to “what professionals should or should not do to impact others, and society in general, in their professional practice” [1]. Given the weight of these obligations, it becomes essential to understand how engineers develop the ethical capacities needed for responsible practice.

Formal engineering education plays a vital role in shaping engineers’ ethical awareness and their commitment to public responsibilities [2]. Despite ongoing efforts to strengthen ethics instruction, current programs show only modest gains in students’ ethical reasoning abilities, suggesting the need for more robust approaches that move beyond awareness to deeper application [3]. To address this gap, ethics education must be research-informed, standardized, and sensitive to the complexities of real-world practice [4]. This suggests that successful ethics instruction requires approaches that reflect the human realities of engineering work.

Ethics cannot be taught in isolation from the human and social dimensions of engineering. Educational approaches that integrate ethics and humanism into the curriculum help prepare engineers to tackle challenges related to sustainability, human rights, and equity in an increasingly technological world [5]. Building on this integrated perspective, our research sought to include both traditional ethical dimensions and issues of equity.

In this study, and we defined equity as “fairness that comes from explicitly considering individual backgrounds and access to resources or opportunities and developing designs that address the unique circumstances of individuals to achieve fair outcomes” contrasting with equality, which is defined as “treating all persons the same regardless of their individual circumstances” [1]. Advancing ethical competence in engineering also requires cultural change at both personal and institutional levels, since technical expertise alone does not foster inclusive or socially responsible practice [6]. Despite increasing diversity in the workforce, gender and racial/ethnic inequality persist, particularly as engineers move up the career ladder toward leadership roles [7], [8]. These ongoing inequities highlight how ethical formation is shaped not only by individual choices but by organizational cultures and social structures.

This transformation involves helping students connect personal moral reasoning to broader social consequences and creating spaces for collaborative dialogue even among those with differing ethical perspectives [9]. However, efforts to reform ethics education must also be grounded in a philosophical understanding of what engineering is for, not merely what engineers do, requiring us to rethink the cultural and educational goals of the profession [10]. These philosophical considerations become particularly pressing when students leave the classroom and enter professional environments.

This is particularly important as graduates navigate the shift from school to work. The transition into professional engineering practice is not just technical; it is deeply social and cultural [11]. New engineers encounter organizational and interpersonal contexts that often challenge the ethical ideals emphasized in school [12]. For example, Intersectional privilege significantly shapes the socialization of newcomer engineers [13]. The presumption of competence is an unearned asset that typically accrues to privileged group of engineers, while women and engineers of color must frequently prove and reprove their technical proficiency [13]. Such dynamics illustrate how the early-career period is a formative, and often vulnerable, stage for ethical and equitable development.

During the formative phase when they are transitioning to the workplace, early-career engineers will navigate identity conflicts, manage competing expectations, and make decisions in environments that may not prioritize equity or public welfare. Research shows that transitioning engineers frequently cross disciplinary and organizational boundaries, developing leadership by navigating these complex spaces [14]. Studies of newly hired engineers show that small group relationships, local mentors, frequent feedback, and accessible information resources significantly enhance workplace adjustment and performance [15]. To succeed, engineers must evolve not only as technical problem-solvers but also as socially skilled [16]. Understanding these complex developmental processes is therefore essential for informing more effective ethics and equity education.

This study uses a three-phase design to examine the experiences of early-career engineers, defined as individuals with five years or less of professional experience [1], with ethics and equity during the critical transition from academic setting to professional practice. The research

offers insights into the ethical formation of engineers for real-world settings and better ways to prepare engineering students.

Overall Project Description

The overall project follows a three-phase, sequential exploratory mixed methods design. Phase one is qualitative (qual), followed by a quantitative phase (QUAN), and concludes with a second qualitative phase (QUAL). The study received Institutional Review Board (IRB) approval from Colorado State University (protocol #1736).

Phase One - Qualitative (qual): In Phase one, 13 semi-structured interviews were conducted with North American engineers. The data were analyzed using reflexive thematic analysis [17], [18], leading to four key themes: (1) Higher education does not fully prepare early-career engineers in terms of ethical and equitable practices. (2) Characteristics of individual workplaces strongly shape the early-career experiences of engineers, including their experiences with ethics and equity. (3) Ethical decision-making influences and processes explained by the participants, highlight how engineers make decisions based on both their personal attributes and the support provided or limitations imposed by their workplace. (4) Self-confidence and self-worth of early-career engineers affect ethical decision making. The findings underscore a disconnect between academic training and professional realities, calling for better alignment between education and practice.

The research from this phase was shared with the engineering education community through a poster and papers presented at the 2024 ASEE Annual Conference and the 2025 ASEE Rocky Mountain Conference. Also, a manuscript detailing the final findings of this phase is currently under review by the European Journal of Engineering Education. At the 2024 ASEE Annual Conference, two papers and one poster were presented. The first paper explored early-career engineers' experiences with ethics and equity in the workplace through thematic analysis of interviews, highlighting challenges in the workplace such as biased treatment, exclusion, and resource allocation [1]. The second paper used interview-based case studies to examine ethical challenges and advocated for experiential, discussion-based ethics education [19]. A poster was shared which summarized the project's progress to date [20]. A formal thesis was submitted to Colorado State University which explores the ethical and equity-related experiences of engineers transitioning from academic setting to professional practice, drawing on semi structured interviews of early-career engineers. The study found that early-career engineers often face ethical dilemmas and feel unprepared for workplace challenges [21]. A notable theme in the study is early-career engineers' reluctance to seek help when needed, highlighting gaps in pre-professional preparation.

At the ASEE 2025 Rocky Mountain Conference, a paper presented that explored what early-career engineers recall about learning ethics and equity in school and the training they receive in the workplace. Three key themes emerged: (1) training in ethics and equity during school is highly variable. (2) the underutilization of the workplace and professional organizations, which serve as a learning environment and offer avenues of ethics and equity learning for early-career engineers. (3) the key role of connecting to society, which influences early-career engineers' ethical and equity perspectives. These findings show the varied pathways through which ethics and equity are learned and applied in engineering practice [22].

Phase Two - Quantitative (QUAN): A novel national survey was conducted with 184 early-career engineers in the United States to explore their experiences with workplace ethics and equity. The study examined how educational backgrounds and work environments influence their preparedness and responses to these issues. This research builds on prior qualitative study of 13 early-career engineers [1], [21].

Participants consisted of early-career engineers with engineering degrees, recruited through several outreach methods. The survey was first distributed anonymously via professional engineering organizations and networks aimed at younger members, with respondents offered a \$25 Amazon gift card as an incentive. This strategy, however, yielded a low number of valid responses and was affected by bot interference. Consequently, the research team amended the IRB protocol to shift from an anonymous to an identifiable survey format. The updated protocol also introduced new recruitment methods, using Qualtrics' paid panel service to specifically reach early-career engineers in the United States with 3 months to 5 years of professional experience. Since the research team used an external service to provide a set number of valid responses, we are unable to calculate the response rate.

In this phase, a quantitative research design was employed to investigate how early-career engineers encounter ethical and equity-related challenges in their professional practice. Quantitative methods allow researchers to collect data systematically and analyze it statistically, converting observations into numerical forms that can be examined using statistical techniques to test theoretical explanations [23]. Using this approach, the research team applied both descriptive and inferential analyses. The dataset was analyzed using RStudio and Microsoft Excel. Descriptive statistics summarized participant demographics, workplace characteristics, and perceptions of ethics and equity, as well as their preparation for professional practice. Inferential statistical methods and advanced modeling techniques were then used to examine relationships among key variables and draw conclusions relevant to the broader population of early-career engineers in the United States.

Preliminary findings from this second phase were presented at the 2025 ASEE Annual Conference [24]. Results indicate that practical, workplace-based experiences have a greater impact than formal academic coursework in preparing engineers to address ethical and equity-related challenges. While participants rated both ethics and equity as important to engineering practice, ethics consistently ranked higher, indicating that early-career engineers view ethical responsibilities as more central to their work than equity and inclusion. There is a journal paper in progress with the final results from phase 2 of the research, to be submitted in the first quarter of 2026.

In phase two, early-career engineers consistently highlighted the critical role of workplace experiences such as hands-on practice, training, and mentorship in shaping their readiness to address ethical and equity challenges. In contrast, academic coursework was viewed as moderately helpful but less influential. Phase three will adopt a qualitative interview design to build on and deepen insights from the first (qualitative) and second (quantitative) phases. Through open-ended conversations, the approach aims to expand, elaborate, and clarify survey findings by drawing on participants lived experiences, personal narratives, and reflective insights.

Phase Three - Qualitative (QUAL): The purpose of this phase of the research is to explore how senior civil engineers perceive the ethical and equity challenges faced by early-career engineers, how they view their own roles in supporting ethical practice, and how workplace systems influence ethical culture. This phase is currently in progress. The decision to interview senior engineers was guided by earlier findings, which revealed that engineering education does not fully prepare early-career engineers for workplace dynamics related to ethics and equity. To address this gap, the research team is interviewing senior engineers to develop a more complete picture of the workplace and to capture how junior and senior engineers may perceive these dynamics differently. Civil engineers represented one of the largest demographic groups in both the first and second phases of this research, and thus this phase will focus on civil engineering workplaces.

The targeted participants are senior civil engineers, defined by the American Society of Civil Engineers [25] as individuals with eight or more years of professional engineering practice. Data collected from these interviews will be analyzed using thematic analysis [26], a method well-suited for identifying, organizing, and interpreting patterns across qualitative datasets. Interviews were selected as the primary data collection method to enable an in-depth exploration of senior civil engineers' perspectives.

Next Steps of the Research

Building on the insights from this study, the next step is to develop a set of case studies paper addressing the ethical and equity challenges faced by early-career engineers. By integrating perspectives from early-career engineers these case studies will provide practical, student-centered applications of the research findings. The resource will serve two critical purposes: (1) enhance undergraduate engineering education by embedding real-world ethical and equity considerations into curricula, and (2) inform strategies for professional practice that support equitable career progression.

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