Learning about Ethics and Equity in Engineering: Experience of Early-Career Engineers

Abstract

Background: As the engineering profession increasingly emphasizes ethical responsibility and equity in practice, the preparation of early-career engineers to navigate these challenges in the workplace is important.

Purpose: This paper aims to report on what early career engineers recall from their learning experiences regarding ethics and equity at school and the training opportunities they receive at their engineering workplace.

Design/Method: Our study employs a qualitative research approach, utilizing reflexive thematic analysis (RTA) to examine the learning experiences and preparation of early-career engineers. As part of a larger study, we interviewed 13 engineers about their learning experiences on issues of ethics and equity at school and work.

Findings: We developed three key themes reflecting the different avenues of learning described by participants. Although the themes may not be surprising, the comments by interviewees give insight into what types of things are learned in these different contexts. The first theme is that training in ethics and equity during school is highly variable. The second theme is the under-utilization of the workplace and professional organizations, which serve as a learning environment and offer avenues of ethics and equity learning for early-career engineers. The third theme is the key role of connecting to society, which influences early career engineers' ethical and equity perspectives. Our findings highlight the diverse pathways through which ethics and equity are integrated into engineering practice.

Conclusion: This study holds practical significance for engineering instructors, educational institutions, and employers in the engineering field. Addressing issues related to ethics and equity in engineering education or practice requires integrating ethics and equity discussions more consistently across engineering curricula and workplace practices to foster a culture of continuous ethical awareness and social responsibility. Also, encouraging engineering students to connect with society and education beyond engineering is an important path to ethical development.

Keywords: ethics, equity, learning experiences of engineers, early-career engineers, reflexive thematic analysis

Introduction

Engineers hold a professional obligation to safeguard public safety and well-being, a duty that underscores the necessity for engineering educators and professional institutions to adequately train engineers in these responsibilities (Cech & Finelli, 2024). However, early-career engineers face numerous challenges during the initial stages of their professional journey, particularly when navigating job role demands and organizational expectations (Jesiek et al., 2021). These

challenges are compounded by a gap in the preparation of engineers for the workforce (Korte et al., 2015; Grajdura & Beddoes, 2022), as engineering education often prioritizes technical competencies over interdisciplinary skills, including those derived from the social sciences and humanities (Josa & Aguado, 2024).

The integration of ethics and societal impacts (ESI) education into engineering curricula has gained increasing prominence, reflected in accreditation standards and institutional priorities (Polmear et al., 2018). However, substantial challenges persist in the effective integration of ethics education into engineering programs, including a lack of faculty expertise in ethics, insufficient institutional support, and a curriculum that tends to treat ethical dilemmas as purely technical problems (Newberry, 2004). These systemic challenges hinder the development of ethical competence among engineering students, as evidenced by Lönngren's (2021) findings of a "culture of disengagement", a concept coined by Cech (2014), in introductory engineering courses, where ethical considerations are marginalized in favor of technical content.

While formal ethics education is important, it alone is insufficient to prepare engineers for the multifaceted challenges they will face in professional practice (Newberry, 2004). The integration of ethics education in engineering curricula represents a significant yet complex challenge in higher education, while teaching ethics is important in engineering education, there's no clear consensus in engineering education on how to do it best (Hess & Fore, 2018). Effective preparation requires deeper structural changes in how engineering education approaches ethics, starting with fostering emotional engagement and integrating ethical reflection into the engineering curriculum (Newberry, 2004). Engineers must transcend traditional technical competencies by combining specialized knowledge with interdisciplinary skills to address complex societal challenges effectively (Josa & Aguado, 2024). The transition from academia to professional practice necessitates not only technical expertise but also adaptability to the cultural and social norms of engineering workplaces (Lutz & Paretti, 2021).

Purpose of the Study

We conducted interviews with 13 early-career engineers to explore their experiences with ethics and equity in the workplace. A prior analysis of these interviews found that many participants felt unprepared to navigate ethical, equity-related, and interpersonal challenges in their professional environments (Agha et al., 2024). Building on that work, this paper focuses on where and how early-career engineers learned about ethics and equity and how their preparation could have been improved.

For this study, an early-career engineer is someone with five years or less of professional experience. The research team defined ethics as "what professionals should or should not do to impact others, and society in general, in their professional practice" (Hedayati Mehdiabadi et al., 2024). Equity was defined 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" (Hedayati Mehdiabadi et al., 2024).

Drawing on participants' recollections of their educational and workplace experiences, this study examines how early-career engineers acquire knowledge related to ethics and equity. By investigating what, when, and where this learning occurs, this study seeks to identify gaps in current preparation practices and propose improvements to better support the transition from academia to professional practice. As the engineering profession places increasing emphasis on ethical responsibility and equity, understanding the role of formal education, post-graduation training, and informal learning environments is essential for fostering more responsible and equitable engineering practices.

Literature Review

Ethics and Equity in Engineering Education

Engineering education must shift from a traditional focus on technical and analytical expertise to incorporating nontechnical skills that emphasize human-centered aspects, enabling students to address societal and human dimensions effectively (Fila et al., 2014). This shift reflects an increasing recognition of equity as a fundamental component of engineering education, representing progressive development in the field (Diduch et al., 2012). A significant body of engineering education scholars has explored the integration of ethics and diversity, equity, and inclusion (DEI) in engineering (Hess et al., 2024).

Despite this growing emphasis, there are significant gaps in the preparation provided by engineering programs. Brunhaver et al. (2021) argue that engineering education often inadequately prepares graduates for the non-technical challenges they face in the workplace. Incorporating ethics at all levels of engineering could create a balanced approach that serves business needs while protecting people and the environment (Murthy et al.,2020). Lutz and Paretti (2021), through interviews with twelve recent graduates, found that transitioning from academia to professional practice entails major shifts in social and cultural contexts. This implies that the workplace context is very different from the academic context in which these engineers were trained.

Ethics education, when effectively integrated into engineering curricula, has been shown to enhance engineers' professional responsibilities and decision-making abilities. Cech and Finelli's (2024) study which utilized survey data from a representative sample of practicing engineers in the United States, found that engineers who received training on public welfare responsibilities during their education are more likely to comprehend their duties to safeguard public health and safety, engage in collective problem-solving, acknowledge the significance of social consequences and ethical responsibilities in their professional roles. Such training also enhances engineers' abilities to identify ethical issues and act when concerns arise in their workplaces.

However, traditional methods of teaching ethics in engineering programs often fall short. Lönngren (2021) suggests that ethics should be integrated throughout the engineering curriculum rather than taught as a separate subject, and advocates for the development of pedagogical strategies. This integrated approach aligns with Rottmann and Reeve's (2020) argument that equity should be embedded within engineering ethics education. Their study, based on interviews with 15 engineers, demonstrates how ethical concerns often intersect with broader societal issues. Their findings highlight the limitations of traditional compliance-based approaches and

advocate for active learning and open-ended case studies, which better prepare students for navigating complex ethical dilemmas in their professional lives.

Ethics and Equity in the Workplace

The early career phase is particularly challenging as engineers adapt to job roles and organizational expectations (Jesiek et al., 2021). The workplace serves as a critical arena where early-career engineers learn about and apply ethics and equity. Vandenberghe (2021) highlights the underrepresentation of minority groups in engineering and posits that professional engineers have an ethical responsibility to foster inclusivity. This involves both personal and professional skill development to create equitable organizational cultures and advocate for inclusive policies and practices.

Studies have also examined the misalignment between academic training and industry expectations. Josa and Aguado (2024), through their survey of 583 participants, uncovered significant disparities in the perception of essential competencies. Their research underscores the urgent need for better alignment between academia and industry to enhance the effectiveness of engineering education and prepare students for workplace challenges. Hess et al. (2023) conducted semi-structured interviews with 43 engineers, emphasizing the importance of these critical incidents in informing educational strategies, suggesting that engineering ethics education should be grounded in the lived experiences of practicing engineers to better prepare engineering students for real-world ethical challenges.

Jesiek et al. (2021), through interviews with 23 early-career engineers, highlight the boundary-spanning activities these individuals undertake. These activities shed light on how early-career engineers navigate organizational demands while progressing in their roles. Similarly, Brunhaver et al. (2021) emphasize the sociocultural challenges faced during this transition, advocating for curricula that integrate training on workplace realities.

While prior research has explored ethics and equity integration in engineering curricula and examined the challenges faced by early-career engineers during the school-to-work transition (e.g., Brunhaver et al., 2021; Jesiek et al., 2021; Rottmann & Reeve, 2020), a critical gap remains in understanding how these engineers continue to learn about ethics and equity once they enter the workforce. Existing studies often focus on formal educational interventions or institutional barriers to inclusion, but they rarely investigate the informal, lived experiences through which early-career engineers develop ethical awareness and equity-centered thinking in practice. Also, the potential of workplaces and professional organizations as learning environments for ethical development remains underexamined. This study addresses these gaps by identifying and analyzing the diverse, real-world pathways within and beyond formal education, through which early-career engineers engage with ethics and equity. In doing so, it highlights underutilized learning spaces and underscores the influential role of societal connection in shaping how early-career engineers think about and approach ethics and equity in their professional lives.

Method

This study uses qualitative research methods (Merriam & Tisdell, 2015), starting with interviews with thirteen engineers. Data were analyzed using reflexive thematic analysis (RTA) (Braun &

Clarke, 2022) to examine college learning experiences, ethics training after school, and other preparations of early-career engineers.

The study received approval from Colorado State University's Institutional Review Board. Participants were recruited through various channels, including social media direct messaging, LinkedIn postings, the researchers' professional connections, and outreach to regional engineering societies and chapters. Participants volunteered for interviews without compensation. The study included interviews with thirteen engineers representing various engineering fields across North America. Pseudonyms were used in this study to protect their privacy.

Our research team employed the six phases of reflexive thematic analysis, as outlined by Braun and Clarke (2022), to ensure a systematic, rigorous, and reliable approach to exploring, interpreting, and presenting qualitative data. This analytical framework provided a structured methodology that guided our examination of the data while allowing for flexibility and depth in interpretation.

The process began with familiarization, where the team thoroughly engaged with the data by reading and re-reading transcripts to gain an in-depth understanding of the content. Next, coding was conducted, involving the systematic identification and labeling of meaningful data segments relevant to the research questions. Following this, initial themes were generated as patterns within the coded data were identified and grouped into potential themes that captured key ideas.

To facilitate this process, our research team utilized ATLAS.ti to inductively code the data, organize the coded data into distinct categories, and identify four key themes. This coding process played an important role in shaping the development of themes, consistent with Braun and Clarke's (2021) emphasis on the dynamic relationship between coding and thematic analysis. Also, Mural software (Mural, 2024) was used to organize the code groups, enabling a flexible and organic exploration of early-career engineers' experiences related to ethics and equity.

Subsequently, our team proceeded to develop and review themes, refining the thematic structure by examining relationships between themes and ensuring coherence and accuracy in representation. In the refining, defining, and naming themes phase, each theme was further clarified, with definitions and descriptions established to accurately convey its essence. Finally, the process concluded with report writing, where the themes were synthesized and presented coherently.

By adhering to this structured yet reflexive approach, our research team ensured a thorough and detailed exploration of the qualitative data, enhancing the credibility and depth of the findings.

Some key questions from the interview were:

- Could you please share a dilemma you have had related to professional ethics in the time since you started working as an engineer?
- Were there specific concepts or skills that you learned during your engineering education that prepared you for this experience/these experiences?
- Could you please share an example of a situation where there were equity or inclusion challenges in the time since you started working as an engineer?
- Were there concepts or skills you learned during your engineering education that helped prepare you for this experience/these experiences?

- Overall, how significant are ethics and equity to your engineering work?

Findings

In the following, we summarize participants' responses to questions regarding how they learned about ethics and equity. The findings reveal three key themes. First, training in ethics and equity during engineering education was highly inconsistent, leaving many early-career engineers underprepared. Second, workplaces and professional organizations offered learning opportunities, but these were often underutilized. Third, many participants developed their understanding of ethics and equity through personal experiences, societal engagement, and non-engineering education. Together, these findings highlight gaps and opportunities in preparing engineers for ethical and equitable practice.

Theme 1: Training in ethics and equity during school is highly variable and could do more to prepare students for work

Early career engineers described various ways in which they were introduced to ethics and equity during their engineering education. Some participants recounted exposure to ethics through technical engineering courses and capstone projects, while others stated that ethics and equity were largely absent from their formal training.

Jade and Bob recalled learning about ethics during their senior-year capstone projects. Jade shared that.

> At (university name) …, my teacher for one of our senior year capstone project classes, put a really big emphasis that you as an engineer and especially as you work your way up, have a responsibility to make good decisions that are going to be beneficial for the people around you.

Similarly, Bob shared, "So, in my undergraduate, … engineering ethics was a course of our capstone class. Much of engineering ethics as it was presented to me was effective."

Others encountered ethics in dedicated courses or integrated discussions within technical subjects. Amos shared about his classroom exposure to ethics during his time at the university. "In my undergrad, … As part of the requirements for my mechanical engineering degree, we did have a dedicated ethics course, which I was very thankful that I had." Jessica shared, "I had a whole course on being an ethical computer engineer." Cesar recalled instances where ethics was discussed in his engineering classes. "… We talked about the engineering code of ethics. And we talked about it (ethics). And we talked about it (ethics) in other classes too." Bangalore also encountered ethics in an engineering course. He shared that "I had a course at [University name] about personality development where ethics, and there were a few other things on the course."

Carl, Alex, Sara, and Spencer stated that their formal education lacked discussions on ethics and equity.

Carl explained that ethics was not part of the curriculum.

> “When I went to school at [University name], it [ethics] wasn't a topic that was covered in the curriculum. I know my exposure to engineering ethics was kind of solely based on what was on the FE [fundamentals of engineering] exam, the ethics portion of that.”

Alex noted that her bachelor’s program did not prepare students for diversity, inclusion, or ethics. Sara also reported that she received no formal training on ethics. Spencer stated, “The equity education I got in college mostly came from my personal life and my side jobs.” Amos critiqued the lack of discussions about societal impacts in formal ethics education courses. He shared, “The bigger discussions about what your work is doing were something that was dodged in my ethics courses.”

These varied experiences highlight inconsistencies in how ethics and equity are addressed in engineering education by instructors. Our participants also gave several suggestions on how their engineering education can be improved. They emphasized the importance of exposing students to real-world engineering challenges early in their academic journey. Bangalore suggests that engineering programs should “[give] ... a glimpse of [the] real-world early on in school, ... for them to kind of get a feel for how challenging the real world is and also rewarding.”

Fred, Bob, Sara, and Spencer underscore the necessity of embedding ethics and equity discussions throughout the curriculum. Fred asserts, “I think it is definitely something that needs to continually be addressed, making sure that ethics and equity and inclusion are key points in engineering education because I think it is really crucial to developing well-rounded engineers.” Similarly, Bob suggests that ethical issues should be explicitly addressed through coursework: “I feel that these things [ethical issues] could be addressed with coursework.” Sara expands on this by emphasizing the value of ethics education in guiding engineers’ professional decision-making: “Education in ethics can help [engineers] understand what is right, what is wrong, and what should be allowed to happen.” Spencer further proposes incorporating socioeconomic ethics into engineering education: “I think overall there could just be more of a focus on more of the ethics side of things in our educational background... maybe more education on socioeconomic ethics.”

Beyond technical competence, workplace readiness is a significant area of concern for early-career engineers. Kaylee states, “I honestly feel like in college, you don't really get introduced to workplace interactions. In engineering ethics classes, they teach a lot about the legal side of things, but for contracts and maybe billing would be the bigger thing.” Alex also highlights a gap in non-technical skill development, noting that while academics prepared her for technical challenges, she was less prepared for workplace dilemmas. If given the opportunity to add coursework, Alex would include topics on how to deal with non-ethical situations, knowing your rights, work loss, and conflict management.

Communication is a critical competency for engineers, yet it remains an underdeveloped skill in many academic programs. Bangalore notes that “[developing] that communication skill set at school... will help you to grow in the industry.” Similarly, Sara emphasizes the importance of presentation skills and public speaking: “I think if I had more skills in presentation skills, public speaking, these kinds of things, that could help me a lot with my job. Because all day long, I'm talking to a lot of people, [...] So if I had better practice with that in school, that would be great.”

Jade suggests that “Encouraging students to engage with larger communities, whether at school, globally, or in their local area, would have a significant benefit.”

Training in ethics and equity during engineering education was highly inconsistent among participants, with some encountering meaningful instruction and others receiving little to none. These gaps often left early-career engineers feeling unprepared for real-world challenges. Participants emphasized the need for engineering programs to embed ethics, equity, and workplace readiness skills consistently throughout the curriculum.

Theme 2: Under-utilization of the workplace and professional organizations

This theme is about how early-career engineers learn about ethics and equity in the workplace and professional organizations. While some participants gain valuable learning opportunities, others report little to no training in their workplace. The workplace includes fundamentals of engineering (FE) exam preparation, on-the-job learning, supervisor support, first-hand exposure to ethical practices, and moral values embedded in daily workplace practices. Also, participation in professional organizations contributes meaningfully to the ethical and equity learning of early-career engineers, although not all participants shared professional organization experiences.

Workplace

Kaylee and Carl’s experiences of preparing for the Fundamentals of Engineering (FE) exam to get a promotion at their respective workplaces aid in ethics learning. Kaylee noted, “A section of that is engineering ethics or ethics in professional practice, so there are a lot of things that are already defined as things that you need to consider.” Carl echoed this, sharing that studying the code of ethics while preparing for the FE exam provided him with foundational knowledge. These experiences highlight the role of self-motivation in supplementing formal education.

Sara’s experience underscores a company’s commitment to fostering a culture of ethical behavior through frequent training sessions and communication. She noted, “We had all kinds of training, … [The company name] care about all things, … not just ethics.” Carl’s workplace integrates diversity, equity, and inclusion training as a quarterly requirement, delivered through virtual modules. He stated, “There’s always one on diversity, equity, and inclusion. So, it’s a requirement.”

Alex’s company takes a systematic approach, providing ethics and integrity training every two months, accompanied by quizzes. He described it as “a staff training on ethics and integrity every two months… an online course and a quiz at the end.”

Cesar’s experience focuses on regular, structured discussions about ethics and equity. He shared,

> “On the first or second day that I started here, we talked about ethics and equity… They always talk about equity every quarter of the year… Everyone just shares what they experience. So, we get courses every quarter here at this company, which is phenomenal.”

Bangalore’s account further illustrates how organizations can weave ethical learning into their daily operations. He described his company's “social contract” as a set of core values discussed at the start of every meeting. Bangalore characterized this approach as “daily training on ethics,” emphasizing its consistency and integration into routine professional interactions.

Fred's account reveals a more superficial engagement with ethical training. He described it as "a box to check when you started the job… It wasn't stressed too much throughout the job." While ethics as a practice was followed, the training lacked depth and ongoing reinforcement. Jessica's account also reveals a significant challenge in the effectiveness of mandatory training. She observed that many coworkers would "just click through it and not actually pay attention," which she attributed partly to the remote work environment without mechanisms to ensure active participation. Also, Jordan highlighted the inadequacy of some ethics training in preparing engineers to handle complex workplace dilemmas. Although ethics training at his job emphasized non-discrimination and inclusivity, he noted, "Do I think it prepared me for dealing with this? Not necessarily." However, he also recognized its value in fostering respectful workplace relationships, which enhanced team collaboration and project outcomes.

What participants shared reveals a spectrum of approaches to formal workplace learning about ethics and equity. On one end, companies like Alex's and Cesar's emphasize regular, meaningful engagement, fostering a culture of continuous learning. On the other end, experiences like those of Fred, Jessica, and Jordan highlight the limitations of perfunctory training methods that fail to engage employees meaningfully.

Professional Organizations

Some professional organizations also play a role in fostering ethical awareness among engineers by aligning learning opportunities with their core values. Bangalore shared how his company supports employees' participation in conferences to promote ethical practices. "I've got a chance to attend a conference. Obviously, they stress about these kinds of things, but most of my experience trying to give importance to ethics or all these values are through the core values of our company." Jade attributed her growth in ethical understanding to her involvement with the Society of Women Engineers (SWE). She explained,

> … from formal events like workshops or conferences, but more […] from my experience of learning and growing, […] and expanding my communities and worldview […]. That has made me pay attention a lot more to how different actions can affect different people.

Similarly, Kaylee's engagement with the Younger Members Forum of the American Society of Civil Engineers (ASCE) offered her opportunities to discuss professional ethics during leadership symposiums. She remarked, "They have a leadership symposium every year that you actually get to talk about professional ethics, which could even be stuff just relating to how you interact with your coworkers and emotional intelligence." Jade and Kaylee's accounts demonstrate how professional organizations foster ethical learning through interaction and discussions.

Although workplaces and professional organizations have the potential to support early-career engineers' learning about ethics and equity, they are often underutilized. Some participants benefited from structured training and active engagement, but others described experiences where ethics and equity were treated as secondary concerns or addressed only superficially.

Theme 3: Key role of connecting to society

This theme is about the interaction of early career engineers with society that goes beyond traditional engineering learning practice.

Jade reflected on how expanding her worldview and interacting with different communities have influenced her understanding of the societal implications of engineering decisions. She stated,

> Just my experience of learning and growing and becoming a person and expanding my communities and worldview... has made me pay attention a lot more to how different actions can affect different people. … It's been more of an organic learning rather than from formal education.

Jade also highlighted how her participation in diverse social justice conversations within her community broadened her understanding of equity and inclusion issues:

> Getting to be part of a community that was more diverse than past experiences ... navigating my way through a world that is much bigger than it was when I was 18 … That led to conversations about equity and inclusion, and learning about social justice movements significantly impacted my understanding of my place in the world.

Cesar underscored the value of serving the community as a foundation for ethical decision-making. He shared, "In one of my classes, we talked about the engineering code of ethics […] and how serving the community [is central to ethical practice]. …you have to trust your gut when doing the right thing, even if others disagree."

Jessica reflected on her character development, explaining, "… It was a lot of introspection and thinking about life. …For me, ethics and equity aren't just workplace concepts; they are more personal, shaped by casual, day-to-day life rather than formal education."

Kaylee recalled learning about ethics from her mother, a civil engineer.

> I kind of grew up around construction and just hearing stories of what she [Kaylee's mother] had to deal with when she was onsite. It's predominantly male, so there's a lot of stuff you've got to deal with. I think no amount of college can teach you what you're going to encounter.

Self-directed learning emerged as another critical pathway for developing ethical competencies. Amos described how reading books on communication and workplace dynamics influenced his approach to handling ethical dilemmas.

> The extracurricular ways have been more from reading books. They're a little more, I don't want to say the stereotypical corporate self-help type stuff, but the crucial conversations books, the burnout books […]. A lot of how I've picked up different things has very much come from communication, and trying to have open discussions.

Some early-career engineers also shared that their understanding of ethics and equity was shaped outside their core engineering courses and reflected on how experiences in non-engineering classes expanded their perspectives and contributed to their ethical development.

Jade, who reported that her understanding of ethics and equity was shaped by non-engineering classes. "Taking English courses for my minor in addition to my engineering classes […] introduced me to a different subsection of the [university name] student body I wouldn't have met otherwise". Kaylee also reported learning about ethics from a non-engineering class. She shared, "I took a sociology class in college; I loved that class."

These shared experiences demonstrate that ethical and equitable engineering practice is deeply influenced by societal interactions, personal growth, and even learning from non-engineering classes.

Discussion of Findings

This study explored how early-career engineers learn about ethics and equity, with a focus on their educational and professional experiences. Findings reveal a diverse range of opportunities for ethical and equity-related learning, though access and engagement vary significantly. Training during school is often inconsistent. In the workplace and through professional organizations, learning opportunities are frequently underutilized. Connecting to society and learning beyond engineering have important implications for how engineers make decisions within their practice.

One of the key findings of this study is the inconsistency in how ethics and equity are integrated into engineering curricula. Ethics is often perceived as a "soft" and secondary subject to technical coursework (Martin & Polmear, 2023). Lönngren (2021) further identifies a pervasive "culture of disengagement" where ethical discussions are marginalized in favor of technical content. These findings align with McGinn (2003), who highlights a significant gap between the ethical education of engineering students and the realities they face in professional practice. Lim et al. (2021) also found that many students struggle to recognize the importance of social and ethical dimensions, focusing instead on technical usability and efficiency. Some participants in our study reported that non-engineering courses played a crucial role in shaping their understanding of ethics and equity.

Conlon (2023) advocates for a more comprehensive approach to engineering ethics that considers both individual actions and the broader social context. As our findings suggest, engineering educators should consider diverse learning processes to better prepare graduates for their professional roles and help them appreciate the interconnected social, cultural, and technical aspects of engineering work (Lutz & Paretti, 2021).

While some early-career engineers reported learning about ethics and equity through various workplace experiences, others indicated that they did not receive formal training in these areas. This highlights a gap in both engineering education and professional development. The participants' stories demonstrate that industry stakeholders are crucial in equipping early-career engineers with the necessary ethical and equity competencies. McGinn's (2003) findings align with our study, revealing the disconnect between formal education and real-world ethical challenges encountered in professional settings. Addressing this gap requires greater collaboration between academia and industry to ensure engineers are prepared to navigate ethical dilemmas effectively.

The stories shared by our participants illustrate that a multifaceted approach is necessary to improve ethics and equity education in engineering. Our findings are in line with the recommendations by Kim et al. (2020), who propose that academic-industry partnerships could provide valuable insights and real-world ethical dilemmas to enrich engineering education. Both academic institutions and industry stakeholders have a significant role to play in ensuring that early-career engineers receive adequate preparation in these areas.

Engineering school and the workplace could do better. But some of our participants told us that there were other avenues of learning about ethics and equity in the early stage of professional practice. We hope this paper provides useful insights that are helpful to engineering educators and contribute to the ongoing discourse on ethics and equity in engineering education and practice.

Practical Implications

The findings from this study call for engineering instructors to integrate practical, context-rich learning experiences, such as real-life case studies and project-based learning, to better equip engineering students for professional practice. Employers of engineers are encouraged to offer tailored programs, workshops, and seminars that include ethics training, diversity initiatives, and fostering ethical decision-making cultures to support ongoing professional development.

Limitations

This study is limited in the following ways. First, the reliance on the study participants' recollections of ethics and equity experiences introduces the potential for recall bias, where memories of past learning experiences may be incomplete or influenced by subsequent events. Secondly, this study used data from engineers in North America, limiting the generalizability of the results, as it may not capture the full diversity of experiences across engineering disciplines, institutions, or various workplace settings in the world.

Acknowledgment

This research is based upon work supported by the National Science Foundation under Grant Nos. 2135328 and 2135329. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References

Agha, C. W., Atadero, R., Omur-Ozbek, P., Scalia IV, J., & Most, D. (2024). Ethical and equity challenges in engineering: A reflexive thematic analysis of early-career engineers' workplace experiences. [Master's thesis, Colorado State University]. *ProQuest*. https://hdl.handle.net/10217/239771

ATLAS.ti Scientific Software Development GmbH. (2024). ATLAS.ti Mac (version 24.0.0.29576) [Qualitative data analysis software]. https://atlasti.com

Braun, V., & Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative research in psychology, 18*(3), 328-352. https://doi.org/10.1080/14780887.2020.1769238

Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide.* Sage Publishing.

Brunhaver, S. R., Jesiek, B. K., Korte, R. F., & Coso Strong, A. (2021). The Early Career Years of Engineering: Crossing the Threshold Between Education and Practice. *Engineering Studies, 13*(2), 79-85. https://doi.org/10.1080/19378629.2021.1961570

Cech, E. A. (2014). Culture of disengagement in engineering education? *Science, Technology, & Human Values, 39*(1), 42-72. https://doi.org/10.1177/0162243913504305

Cech, E. A., & Finelli, C. J. (2024). Learning to prioritize the public good: Does training in classes, workplaces, and professional societies shape engineers' understanding of their public welfare responsibilities?. *Journal of Engineering Education*, *113*(2), 407-438.

Conlon, E. (2023). Engineering ethics, social theory and how we might do better!. In *Engineering, Social Sciences, and the Humanities: Have Their Conversations Come of Age?* (pp. 221-243). Cham: Springer International Publishing.

Diduch, C., MacIsaac, D., Haralampides, K., & Wilson, B. (2012). Engineering and social justice through an accreditation lens: Expectations and learning opportunities for ethics and equity. *Proceedings of the Canadian Engineering Education Association (CEEA)*.

Fila, N. D., Hess, J., Hira, A., Joslyn, C. H., Tolbert, D., & Hynes, M. M. (2014). The people part of engineering: Engineering for, with, and as people. In *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, (pp. 1-9). IEEE.

Grajdura, S. A., & Beddoes, K. (2022). What early career civil engineers wish they had done differently: Lessons for students and faculty. In *American Society for Engineering Education Annual Conference.*

Hedayati Mehdiabadi, A., Agha, C. W., Atadero, R. A., Omur-Ozbek, P., & Duenninger, C. (2024). Early-Career Engineers' Stories of Ethics and Equity in the Workplace: A Thematic Analysis. In *2024 ASEE Annual Conference & Exposition*. https://doi.org/10.18260/1-2--47211

Hess, J. L., & Fore, G. (2018). A systematic literature review of US engineering ethics interventions. *Science and Engineering Ethics*, *24*(2), 551–583. https://doi.org/10.1007/s11948-017-9910-6

Hess, J. L., Kim, D., & Fila, N. D. (2023). Critical incidents in ways of experiencing ethical engineering practice. *Studies in Engineering Education*, *3*(2), 1-30.

Hess, J. L., Lin, A., Whitehead, A., & Katz, A. (2024). How do ethics and diversity, equity, and inclusion relate in engineering? A systematic review. *Journal of Engineering Education*, *113*(1), 143-163. https://doi.org/10.1002/jee.20571

Jesiek, B. K., Buswell, N. T., & Nittala, S. (2021). Performing at the boundaries: Narratives of early career engineering practice. *Engineering Studies*, *13*(2), 86-110.

Josa, I., & Aguado, A. (2024). Exploring perceptions of social and generic competencies among engineering students, professors, and practitioners. *Journal of Civil Engineering Education*, *150*(4), 04024002. https://doi.org/10.1061/JCEECD.EIENG-1955

Kim, D., Jesiek, B. K., Zoltowski, C. B., Loui, M. C., & Brightman, A. O. (2020). An academic-industry partnership for preparing the next generation of ethical engineers for professional practice. *Advances in engineering education*.

Korte, R., Brunhaver, S. R., & Sheppard, S. (2015). (Mis)interpretations of organizational socialization: The expectations and experiences of newcomers and managers. *Human Resource Development Quarterly*, *26*(2), 185–208. https://doi.org/10.1002/hrdq.21206

Lim, J. H., Hunt, B. D., Findlater, N., Tkacik, P. T., & Dahlberg, J. L. (2021). "In our own little world": Invisibility of the social and ethical dimension of engineering among undergraduate students. *Science and Engineering Ethics*, *27*(6), 74.

Lönngren, J. (2021). Exploring the discursive construction of ethics in an introductory engineering course. *Journal of Engineering Education*, *110*(1), 44-69.

Lutz, B., & Paretti, M. C. (2021). Exploring the social and cultural dimensions of learning for recent engineering graduates during the school-to-work transition. *Engineering Studies*, *13*(2), 132-157.

Martin, D. A., & Polmear, M. (2023). The two cultures of engineering education: Looking back and moving forward. In *Engineering, Social Sciences, and the Humanities: Have Their Conversations Come of Age?* (pp. 133-150). Cham: Springer International Publishing.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation* (4th ed.). John Wiley & Sons.

McGinn, R. E. (2003). "Mind the gaps": An empirical approach to engineering ethics, 1997–2001. *Science and Engineering Ethics*, *9*, 517-542.

Mural. (2024). Mural [Computer software]. Tactivos, Inc. https://www.mural.co.

Murthy, J. N., Lavanya, C., & Kosaraju, S. (2020). Ethics in engineering profession: Pedagogy and practices. In K. Kumar & J. P. Davim (Eds.), *Methodologies and outcomes of engineering and technological pedagogy* (pp. 296-318). IGI Global. https://doi.org/10.4018/978-1-7998-2245-5.ch014

Newberry, B. (2004). The dilemma of ethics in engineering education. *Science and Engineering Ethics, 10*(2), 343–351. https://doi.org/10. 1007/s11948-004-0030-8

Polmear, M., Bielefeldt, A., Knight, D., Swan, C., & Canney, N. (2018). Faculty perceptions of challenges to educating engineering and computing students about ethics and societal impacts. *Proceedings of the ASEE Annual Conference & Exposition*, Salt Lake City, UT. Retrieved from https://peer.asee.org/30510

Rottmann, C., & Reeve, D. (2020). Equity as rebar: Bridging the micro/macro divide in engineering ethics education. *Canadian Journal of Science, Mathematics and Technology Education*, 20, 146-165. https://doi.org/10.1007/s42330-019-00073-7

Vandenberghe, J. (2021). How professional engineers can contribute to attraction and retention of minority groups into the engineering profession through equity, diversity, inclusion, and decolonization efforts. *The Canadian Journal of Chemical Engineering*, *99*(10), 2116-2123.