Identifying Critical Incidents Related to Ethics Among Early-Career Engineers

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***Abstract*—This paper uses the critical incident technique to analyze how early career engineers experience ethics in the workplace. Our results build off a previously developed framework that categorizes critical incidents related to professional engineering ethics, but we expand the framework to address its gaps. Though there was significant overlap between our findings and the existing framework in the types of critical incidents reported by participants, in some cases the severity of a negative ethical experience was not captured by existing categories, especially when describing sexual harassment in the workplace. Many incidents also required multiple categories to accurately describe them as opposed to a single overarching descriptor. Additionally, we observed a connection between personal morality and professional ethics that was present in some critical incidents. Our observations suggest that similar types of critical incidents related to ethics may often be experienced by engineers, but more work needs to be done to expand the classification of these situations and better understand how engineers develop ethics-related competencies, especially early in their careers and in a workplace context.**

Keywords—critical incidents, engineering ethics, early-career engineers

I. Introduction

Much of the prior research on engineering ethics has focused on how to develop ethical competencies in engineering students to meet societal needs and expectations, satisfy program accreditors, and encourage professionalism [1]–[3]. Far less work has explored the ethical experiences of practicing engineers. Investigating the impact of workplace incidents on early-career engineers' understanding and practice of professional ethics could lead to the creation of more effective ethics instructional methods and materials, while also contributing to efforts to make the engineering profession more ethical and socially responsible.

In this paper, we use a critical incident technique (CIT) approach [4] to explore specific incidents of how early-career engineers experience ethics in the workplace or graduate studies. To do this, we completed twenty semi-structured interviews with engineering professionals within 1-3 years of completing their undergraduate degrees. These professionals possessed bachelor's degrees from a variety of engineering disciplines and were working in diverse industries. The interviews included a wide range of questions which probed the participants' definitions of ethics and social responsibility, ethical situations they have encountered, the ethical climate of their workplace, and their perspectives on ethical scenarios presented on a prior survey.

Our analysis builds upon other studies that have used CIT to explore the experiences that impacted the ethical perspectives of practicing engineers [5] and prior work by our team investigating various types of settings and experiences where engineering students reported learning about ethics [6]. In this paper, we use CIT to identify the types of ethical situations that engineers in our study report encountering, the specific ethical issues involved in those situations, and the impacts of such situations on early career engineers' ethical understandings. This work will add to the scholarship on how engineers are socialized to ethical norms within engineering early in their careers, including the incidents or experiences critical for their ongoing ethical development.

II. Background

The school-to-work transition is a critical period to study given that ethics is consistently identified as an important competency for practicing engineers by many stakeholders [1], including by early-career engineers themselves [7]. Research indicates that many recent graduates do not feel prepared for the complexities of professional practice [7]–[9]. Further, there is evidence of differences in how ethics and related concepts are conceptualized and prioritized in different engineering fields, both in higher education and industry settings [10]. Previous work has investigated the experiences and challenges of students transitioning into engineering practice [11], but a specific focus on the ethics-related experiences faced in this transition is lacking in the literature.

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This study uses a subset of interviews from a broader longitudinal mixed-methods study on engineering students' and engineers' perception of engineering ethics and social responsibility. This study builds upon previous work which included thematic analysis and narrative techniques to investigate a wide range of experiences that influence student perceptions of engineering ethics and social responsibility [6], [12]. The use of CIT presents a unique opportunity to expand these insights and explore the shared types of ethics-related incidents early-career engineers experience in the workplace.

The application of CIT in the context of engineering education has been argued for because of the technique's ability to draw out rich data that aids in the development of grounded theories [13]. In the context of engineering ethics, CIT was applied by Hess et al. [5] to investigate engineers' experiences with ethical practice in the health products industry. As part of their analysis, Hess et al. [5] developed five primary categories of workforce-related incident types and several subcategories within them. This was a subset of the broader categories identified by Kim et al. [14], which had been narrowed to workplace-related incidents in the study reported in Hess et al. For our study, we applied the workplace-related categories in an effort to categorize the types of ethics-related critical incidents that the early career engineers in our study reported experiencing. The use of the Hess et al. framework allows us to identify areas for expansion or improvement that can be used in future research.

III. Methods

The data used in this study are a subset of interviews from a broader longitudinal mixed-methods study on engineering students' and practicing engineers' perception of engineering ethics and social responsibility [12], [15], [16]. The participants for this study were previously interviewed at the beginning and end of their engineering education (as first-year and fourth-year students). A third round of interviews was conducted after they had graduated and either started work in an engineering-related field or enrolled in a graduate degree program. For this study, we focus our analysis on the third set of interviews which examined participants' current perspectives and experiences post-graduation. The interviews were semi-structured and included questions that asked participants to describe ethical experiences, their perception of ethics and engineering ethics, and to elaborate on their responses from a survey they completed prior to the interview. The audio from each interview was recorded and then transcribed by an automated transcription service, Otter.ai. The transcripts were then cleaned by research assistants for accuracy, punctuation, and anonymity. All procedures were carried out under appropriate approvals for human subjects research granted by Purdue University and San Francisco State University.

We completed a total of 20 semi-structured interviews with engineering professionals within 1-3 years of completing their undergraduate degrees. Of these 20 interviewees, a total of 12 participants identified their gender as male, seven as female, and one as non-binary. All were within the age range of 21 to 24 years old, with an average age of 22.1. 16 participants reported working as engineers, or in a similar industry, and four were enrolled in graduate school. There were seven participants from Brigham Young University, six from Colorado School of Mines, and seven from Purdue University. The participants earned a variety of engineering and technology related degrees, with three participants who studied manufacturing/industrial systems, two chemical/biochemical engineering, two civil engineering, three electrical/computer engineering, one information technology/computer science, five mechanical engineering, two materials/metallurgical engineering, and two who studied biomedical engineering.

A. Data Analysis

The critical incidents were identified through iterative coding of descriptions of ethical scenarios the participants had encountered prior to the interview. Initially, two research assistants read through interview transcripts to identify ethical scenarios and potential critical incidents according to the following criteria laid out by Butterfield et al. [17] and further utilized by Hess et al. [5]:

1. The presence of antecedent information.
2. A detailed description of the experience.
3. An outcome that shows a clear change in perspective or behavior.

To be classified as a critical incident, the experiences need to have sufficient context, a description of the incident itself, and a clear impact on the participant. The ethical scenarios identified as potential incidents by the two research assistants were then reviewed by the first author to determine if the scenarios could be considered a critical incident based on the above definition. While most of the participants were able to describe an ethical scenario they had experienced in the workplace, some of these experiences lacked a clear outcome required to classify it as a critical incident as required by the third criterion. The participants' ethics experiences that did not include elaboration on how the experience influenced their perspective and behavior were excluded from this analysis.

Once the critical incidents were identified, the first author applied the specific critical incident categories and incident types identified by Hess et al. [5] as an initial theoretical framework for coding. The five primary workplace-related incident categories identified and used to code this data set are:

- Cultural Immersion
- Interpersonal Encounters
- Ethical Actions
- Ethical Failures
- Mentorship Events

These categories each have several refining sub-categories or incident types that Hess et al. also identified, such as separating ethical failures into technical and personal failures [5]. The incidents were labeled according to the category and incident type that fit best. Any incidents that did not fit within the framework were also noted as such.

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IV. Results

Four important findings emerged from our analysis. First, we observed significant overlap between the incidents described by our participants and the categories developed by Hess et al. [5]. Second, we observed incidents described by our participants which were grave in subject matter and seemed to go beyond what could be captured by established categories. Third, we observed cases where the participants made connections between their encounters with engineering ethics and their personal morals, a theme that was not previously reflected in Hess et al.'s workforce-related incident categories but was part of their broader incident categories [14]. Finally, we observed a correlation between incident types within the experiences described by participants. We describe these four major findings here.

A. Fit with Previously Identified Incident Types

Nearly every critical incident identified in our data could fit into one of the categories and incident types described by Hess et al. [1] and often fell within multiple incident types. Using their framework, we categorized eight instances of *cultural immersion*, seven of *interpersonal encounters*, 20 of *ethical actions*, six of *ethical failures*, and four of *mentorship activity*. The number of critical incidents is greater than the number of participants because many of the participants experienced and described multiple types of critical incidents, or because the critical incidents they experienced could be classified into multiple categories. The large number of critical incidents that can be described by the Hess et al. framework shows that it is an excellent fit for the critical incidents we collected. One example that illustrates this fit is Brody's experience with a safety emergency:

> I remember one situation, I was there, me and this other guy were the only salaried people in the building. And there were, there was a safety incident that I had to attend to. There's nobody there to drive the plant ambulance, right? […] I had to make the decision, like, am I going to just go take the ambulance and ask for forgiveness later? […] Or am I gonna sit here and let this person bleed out, while I call the safety guy […]? And so I feel like if it's someone's well-being, health, personal life, whatever, then I don't want to say you can make exceptions, but it maybe changes the weight of your decision a little bit.

In this incident Brody had to make a quick ethical decision between following the company's protocol or breaking protocol to help an injured coworker. He decided the consequences of driving the plant ambulance without permission were trivial compared to the well-being and health of the injured person. Brody's experience can be classified as an *ethical action*, and specifically as the incident type *steadfast ethical action* because Brody's remarks suggest he is learning through ethical action and staying the course of what he believes to be ethical in a particular situation.

Another example of an incident that fits within the established incident types is Parson's experience during a co-op with a study his company conducted. Parson was particularly impressed by the company's commitment to privacy and ethical practice. As he explains:

> For example, privacy is like a thing that they really focus on in their products and their advertising and everything. […] I worked on the [Consumer Product] teams. We would set up studies to test new sensors on people. […] And for signed, consenting, paid participants, they still enforced all of the privacy restrictions that they do for [paying customers]. […] If like a device was stolen, [there was] useful data for us that we couldn't [access] because of their, their privacy policies and their ethics. So that was really, that was one unique insight that I've had, I guess, in a good way, because to see a company that big, with that much money, to be frankly, still observing, and trying to do the right thing, even at the lowest level of management. That was really inspiring. It kind of showed me that it could be done.

This incident can be considered an example of a *cultural immersion*, specifically the incident type *immersion in workplace culture*. Parson described the experience as "inspiring" and was impressed that a large corporation can follow their ethical standards at a variety of levels. Parson's experience highlights how he was immersed in the values that the workplace culture deemed important. The company could have collected more data for their own benefit, such as their participants' locations, but chose not to because of their culture and respect for their study participants' privacy.

These examples fit within the established categories and suggest the categories established by Hess et al. [5] are a useful tool to identify the types of experiences that influence the development of engineers' perceptions of professional ethics. While the majority of the critical incidents we identified fit into these previous categories, there were instances where the critical incidents went beyond what had previously been observed. These extensions and divergences will be the focus of the remainder of the results.

B. Severity of Negative Interpersonal Encounters

One type of critical incident identified within our data which was not covered by the categories was extremely negative or malicious workplace interactions. The category "Interpersonal Encounters" addresses some aspects of difficult workplace interactions with incident types such as "questionable behavior observations," "difficult collaborations," and "non-belonging encounters" [5]. However, some of the interpersonal interactions described by our interviewees go beyond questionable or difficult and enter the realm of malicious or explicitly unethical.

One example of an extremely negative interpersonal encounter from our data was an experience with sexual harassment in the workplace. Petunia shared an incident where one of her coworkers repeatedly asked her to go on a date and requested her social media contact information in a manner that made her uncomfortable. As she explained:

> One of the guys who like builds carts and stuff […] kept asking me out, asked me for my Snapchat, kind of all this kind of stuff. And I was like, no, I don't want to, you know. And then eventually, I needed him to build a cart for me, and he said, he'd only do it if I, you know, gave him my social media and did stuff like that. And I was

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> like, no, no, no. And at that time, [I said], you know, I'll deal with it. Like, I don't really care. But another guy who was working with me on the project, I casually mentioned it to him, and he […] was like, 'That's not right. […] It's quid pro quo. […] You shouldn't be dealing with that.' And so he reported it to our manager, and they kind of escalated that and did stuff with HR […]. So I think that is kind of just an example too, of […] those good people that […] look out and report when something isn't, isn't right.

As Petunia reports, the harassment from her coworker reached a point where it interfered with her ability to do her job because she could not access the tools or support she needed without divulging her private information. Even though she did not report it initially, the behavior was so egregious that another coworker reported it to human resources for Petunia as soon as he learned about the situation. A key part of the outcome of this incident is Petunia's appreciation for the coworker who reported her harasser. Despite the negative experience, she is still optimistic that there are good people who will stand up for what they believe is right.

If the framework is applied here, Petunia's experience would be categorized as an *interpersonal encounter* because she learned from her interactions with others; however, her experience does not fit into the incident types listed under this category. Petunia's interactions with her harasser could be considered a *difficult collaboration* or a *non-belonging encounter* but these descriptors miss the targeted and personal aspect of her experience. Hess et al. describe a "non-belonging encounter" with an example where a female engineer was assigned to a task and the client specifically asked for a male engineer instead [5]. While Petunia's experience reflects similar patriarchal gender dynamics, there is a clear difference between a sexist customer and a coworker sexually harassing another coworker. To describe Petunia's experience as non-belonging greatly downplays the severity of the incident.

Another example where the malicious behavior of a coworker goes beyond the established incident types is Carly's experience at her first engineering job out of college. In that job, Carly received inadequate training for her position which, compounded with her boss' negative influence, made her question whether she should even be an engineer. As Carly explained:

> I got, like, basically no training at all on my last job. And so I was like, "Oh my God, I don't know how to do anything." And I was really stressed out. I felt like I didn't deserve to be there. And also my, my like, boss was not helpful with that […] They told me that I was responsible for the money that the company was losing, and stuff like that, which I think is not true. Because, you know, after I'd only been there for like six months, I shouldn't have had enough power to lose money from the company. […] Since I hated it so much, […] I didn't know if it was just […] that one company that was like that, or if it's all engineering, or if I should even be an engineer.

Carly's interaction with her boss could also be considered a "non-belonging encounter" because she specifically mentioned her doubts about herself and about the entirety of engineering as a field, but the severity of this experience suggests that it goes beyond non-belonging. Carly's description of how her boss was blaming her for the company's lost money, despite her lack of experience and training, highlights malicious behavior of a more severe and targeted nature.

Despite how both incidents fit into the categories and incident types previously identified, the gravity of the topics discussed necessitates greater consideration and nuance than the established classifications currently accommodate. An extremely negative workplace incident may cause serious impacts beyond an engineer's professional behavior or perspective on professional ethics, such as Carly reconsidering her entire career path, and affect an engineer on a more personal level. Consequently, the development of a new incident type within the *interpersonal encounter* category that addresses severe negative experiences in the workplace would be incredibly beneficial to evaluate shifts in ethical perspectives.

C. Personal Morals and Professional Ethics Connection

Other incidents, less serious in nature than those described in the last section, also went beyond the bounds of professional ethics and pointed towards a more integrated relationship between personal morals and professional ethics. One example of this connection between the personal morality and professional ethics came from Braxton's experience as an engineer. He shared how unauthorized account sharing is a common practice in his workplace and how this relates to his developing sense of how ethically "gray" situations can be, not just in the workplace. As he explained:

> We're using an account that we didn't pay for, sort of thing. It's the sort of ethical thing where I was like, if this is a small business that really relies on our patronage, that's more of an issue to me than this massive corporation. Which is what we were using […] – a multibillion-dollar company. Right? To me, that's like, okay, they're not going to miss $10 this one month, right? You know, and so to me, that's kind of where it becomes this gray area of like, theft is bad. Is this theft? […] There's just a lot more that goes into it, if that makes sense […] But I mean, I guess as I have grown up and I have kind of become more aware of, I guess, the realities of, of how things work, I see that there is not always an easy answer. I think it's the inner 12-year-old saying, 'The world is black and white.' And me not wanting to admit that I am living in the gray area in something. I guess there's also an element of like just uncertainty at my own ethics as I have grown and changed. And like not fully knowing where I stand on everything yet.

This incident could be categorized as *cultural immersions,* and more specifically *workplace cultures* or *cumulative experiences*. As Braxton spends time in the workplace and experiences professional ethics, his understanding of morality shifts and grows as well. He expressed tension between his understanding of theft and how that relates to account sharing

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in a professional setting; however, he did not provide a concrete answer to his self-imposed question of "is this theft?" The outcome of this incident is not present in Braxton's professional behavior, but present in his personal moral development. He described an uncertainty in his own ethical standings that evolved from his "inner 12-year-old" sense of right and wrong, which is reflected in his more nuanced perspective on the account sharing issue. The exact degree to which Braxton's workplace experiences with professional ethics influenced his perceptions of personal morality is unclear, but he does express some relationship between professional ethics and his personal moral development.

Conversely, Bagheera's experiences with ethics outside of the workplace influenced how he perceived professional ethics and the people he worked with. More specifically, Bagheera reflected on how he volunteered for an administrative position at his church that gave him access to financial information of the fellow members of his congregation:

> As I was participating with the local congregation there, I had the opportunity to serve as, as it was called, the ward clerk. So, I was in charge of administering the kind of membership records and the awards, financial records, and finances generally. And in that capacity that gave me the opportunity to […] have a window into a lot of issues that that people were having as individuals, as families. And I guess that kind of opened my eyes a little bit more to reality and, and the kinds of struggles that people face that otherwise I would have been totally unaware of. And so, I think understanding the magnitude of difficulty that people can face has kind of helped me in my professional life to, first of all, be more sympathetic and empathetic towards the people I work with. But also, to realize and recognize the kind of pressures or factors that might be affecting people in their professional decision making.

The reported incident occurred in a non-workplace setting, but the consequent insight is linked to a professional setting and is connected to a change in how Bagheera perceived professional interactions. He developed a greater sense of empathy for the people closest to him and extended that empathy into the workplace to recognize factors that affect professional decision making. Similar to Braxton, the boundary between personal morality and professional ethics seemed to blur as Bagheera reported that the ethical realization in his personal life impacted his view on professional ethics.

D. Incident Type Crossover

Another commonality across the participants' critical incidents was the overlapping nature of many of the incident types. Hess et al. acknowledge a similar observation in their own analysis but chose not to report on such instances in their paper. In our data, we observe incidents that can be categorized into multiple categories and subcategories but also observe that some incidents require multiple categories to fully describe the event. For example, Penelope described an incident where she had difficult collaborations with a vendor who repeatedly fell short of her expectations:

> So like a year ago, I was working with this vendor who was making me really mad. They were, they had completely failed at everything that they told me that they would do. And it was affecting thousands of residents […] We had bought a bunch of hotspots, like 2,000 from them, and then they all went offline at the same time. And this happened at two different instances within a six-month period. So, I was ready to go after them and yell at them and call them awful people, which is not the case. Like they're fine people, they just didn't run a very smooth business. But I went to [my mentor] first and so glad that I did because he [showed me that] just because you disagree with somebody doesn't mean you have to burn bridges, or insult somebody's business practice even if you don't agree with them[…] I brought him into a meeting with a vendor and talked as much as I should have. […] And then he would come in with some remediation like, okay, here's what we're gonna do to remediate the situation or to terminate the contract.

Penelope's frustration with the vendor can be classified as an *interpersonal encounter*, specifically a *difficult collaboration*. Her decision to discuss the situation with a mentor and bring him into the meeting to act as mediator could also be classified as a *mentorship event*. This incident fits two incident types, but the mentorship event is dependent on the difficult collaboration. Here, both incident types identified lead to the outcome in distinct parts. The *interpersonal encounter* with the vendor resulted in Penelope feeling upset enough that she felt her professional ethics might bend to allow her to "go after them and yell at them." However, the *mentorship event* taught her how to handle the pressure of the interpersonal event through mediation—effectively changing her behavior within her developed professional ethics. Without the vendor causing an ethical scenario around professionalism, Penelope would not need to reach out to her mentor to help moderate the meeting. The causal relationship between the two incident types suggests that basic categorization of incidents may not be adequate to fully capture the essence of the critical incident. The connections between incident types significantly adds to the description of the entire incident in a way that is not captured with the Hess et al. framework.

Another example of the interconnected nature of critical incident types can be found in an incident reported by Phineas that involves an experience with research funding as a doctoral student and context that conflicts with their own personal values. In this incident, Phineas elevated their concerns to their project advisor.

> I remember running into all of the literature on the predatory recruiting practices of the [Government Agency], and feeling very conflicted about how I was then supposed to make this educational promotion of recruitment practices for the [Government Agency] […] and then going, I don't want to report this, I don't want to do this. And so then going around and be like, well, I'm not going to say how the [Government Agency] should recruit, I'm going to say how we can recruit, how anybody can recruit for a diverse population, like for recruit inclusively. […] I told my advisor, "I don't like

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that and I don't want to do it," and she's like, "I don't like it either. So don't do it."

Phineas faces an *inconvenient ethical action* according to the Hess framework because they had to navigate between their own ethical values and the needs of the government agency stakeholders. By producing the promotional content using the agency's "predatory recruiting practice" guidelines, Phineas felt that they were violating a form of social responsibility and did not want to fulfill the agency's need. However, Phineas felt compelled to appeal to their research advisor for advice and to validate their ethical decision, which can be classified as a *mentorship event*. The need Phineas felt to discuss the ethical uncertainty with their advisor is dependent on the *inconvenient ethical action*. This once again underscores how multiple categories may be necessary to fully describe and characterize a critical incident.

V. Discussion and Conclusion

The findings reported above reflect considerable resonance with prior work by Hess et al. [5], but also identify divergences and extensions. In light of our findings, it is worth noting a significant distinction between the participants discussed in each paper. The Hess team focused on the experiences of engineers working in the health products industry while our participants had more diverse disciplinary backgrounds and worked in various industries. Additionally, the participants interviewed by Hess et al. had a much wider range of job experience, including people who had been working for nearly 40 years. Our participants were all early-career engineers who had only been working full time for a few years. Despite these population differences, the applicability of the incident types described by Hess et al. [5] suggest that there are critical incidents likely relevant across engineering fields and applicable at varying levels of experience. Future research could be conducted to identify more incident types, how the incident types relate with each other, and how those new types of incidents impact the individuals experiencing them.

The applicability of the Hess et al. framework, despite the demographic differences between our respective participants, also suggests that the categories of critical incidents may have some educational value when teaching engineering ethics to students and perhaps also professionals. The results of this paper suggest there are types of critical incidents related to engineering ethics that may be common across disciplines and experience. These incident types can be used in the development and analysis of realistic case studies that can be used to teach engineering ethics. Students may also benefit from educational activities that embrace the ethical complexity that is present in many real-world engineering problems and was also present in the critical incidents described in this paper.

An aspect of the critical incidents experienced by early-career engineers that we were unable to capture is the narrative of how these critical incidents help the engineers ethically develop beyond the immediate outcome of the incident. Many of the participants experienced professional ethical challenges for the first time as part of their work and learned how to navigate them as part of the experience. The journey from ethically unsure to a more developed sense of ethics as an engineer is present but required a level of analysis that went beyond the scope of this paper. In this paper we focus our attention on using the Hess et al. workplace-related incident framework to categorize and identify critical incidents rather than tracing their effects on the ethical development of the individual participants. Deeper analysis into individual participant interviews could further illustrate how the participants develop ethically in response to their career experiences and how multiple experiences combine for participants to create a more complete narrative about becoming an ethical engineer.

The interconnected nature of critical incident types observed in this paper also suggests it may be beneficial to move away from rigid category descriptions and towards the development of a more robust method to describe ethical experiences. The identification of multiple incident types for a single incident suggests that a single category approach may not be sufficient to describe the critical incidents and ethical scenarios that practicing engineers encounter. The ethical challenges engineers experience in the workplace are often complicated with multiple stakeholders and conflicting ethical principles, so the categorization and descriptions of these experiences should reflect this complexity. The examples shown in this paper also highlight how some aspects of these ethical challenges are dependent on each other, where one ethical dimension leads to another and so on. Future descriptions of critical incidents and ethical scenarios may benefit from a more holistic description rather than an attempt to distill the incident into its simplest form.

Additionally, the connection between personal morals and professional ethical development observed in this paper suggests that future analysis of ethical development among engineers should avoid drawing a rigid boundary between engineering workplace-related ethical experiences and personal moral considerations. We found the two additional categories reported in Kim et al. [14], namely 1) *reflection and association* and 2) *prior ethics training*, were identified as critical incidents by our participants when describing their experiences as early career engineers. There are ethical challenges that are exclusive to engineers and technical jobs, but the way engineers engage with these challenges does not occur in a vacuum. An engineer brings their past experience and personhood into the workplace and cannot be expected to shed their identity completely to analyze and navigate ethical problems they experience at work. Future attempts to capture this more complete picture of an engineer could highlight aspects of professional ethics development that are not directly connected to their work or university experiences.

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