Board 419: Students use their Lived Experiences to Justify their Beliefs about How they Will Approach Process Safety Judgment

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Dr. Elif Miskioglu is an early-career engineering education scholar and educator. She holds a B.S. in Chemical Engineering (with Genetics minor) from Iowa State University, and an M.S. and Ph.D. in Chemical Engineering from Ohio State University. Her early Ph.D. work focused on the development of bacterial biosensors capable of screening pesticides for specifically targeting the malaria vector mosquito, Anopheles gambiae. As a result, her diverse background also includes experience in infectious disease and epidemiology, providing crucial exposure to the broader context of engineering problems and their subsequent solutions. These diverse experiences and a growing passion for improving engineering education prompted Dr. Miskioglu to change her career path and become a scholar of engineering education. As an educator, she is committed to challenging her students to uncover new perspectives and dig deeper into the context of the societal problems engineering is intended to solve. As a scholar, she seeks to not only contribute original theoretical research to the field, but work to bridge the theory-to-practice gap in engineering education by serving as an ambassador for empirically driven educational practices.

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Students use their lived experiences to justify their beliefs about how they will approach process safety judgments

Introduction & Background

Engineering judgment is a critical function to the profession, especially in the chemical process industry, because of potential implications on human safety, economics, and environmental wellbeing [1]–[3]. Making judgments in contexts with competing criteria (e.g., leadership, production, relationships, safety, spending, time) is inherent to the role of an engineer [4]. For example, an incident case study investigated by the US Chemical Safety and Hazard Investigation Board (CSB) describes how an engineers' judgment when selecting a type of hose involves consideration of several criteria: cost of hose options (spending), replacement frequency from hose degradation (time), toll on productivity from subsequent down time (production), and safety risk to workers replacing the hose (safety) [5].

Engineers are traditionally taught to approach process safety through hazard management training, such as HAZOP and LOPA [6], [7]. Yet, contextual factors may influence engineering judgments, resulting in behaviors that differ from their initial beliefs. For example, in another process incident case study, the CSB describes how engineering decision makers neglected to call for a plant shutdown during a hazardous chemical leak over concerns of productivity and "flack" from colleagues [8]. In this case study, engineers described safety priorities, but they behaved differently when challenged by contextual factors, such as relationships with coworkers or production expectations from employers. Throughout their education, engineering students may form oversimplified beliefs based on classroom experiences or internships [9], [10], such as how they will approach making safety related judgments or manage the demands associated with these process safety criteria. As such, a lack of formative experience in making judgments or recognition of how criteria may conflict may lead to inadequate awareness as to how they tend to actually approach making judgments.

Awareness of how we approach judgments may be established by reconciling espoused beliefs with actual behaviors [11], [12]. In doing so, individuals may be able to critically reflect on and account for their tendencies when approaching future judgments. Such reflections would likely create awareness of the gaps which can exist between our espoused beliefs and behaviors [13], which may in-turn reduce judgments that contribute to process incidents. Generating awareness through the process of critical reflection is well established in implicit bias training [14]–[17].

The objective of this project is to provide senior chemical engineering students with an opportunity to evaluate their own self-held beliefs by holding their espoused beliefs up to their own judgments made in a simulated environment. We constructed a model (Figure 1) to illustrate how, along with espoused beliefs, multiple factors contribute to an engineers' judgment.

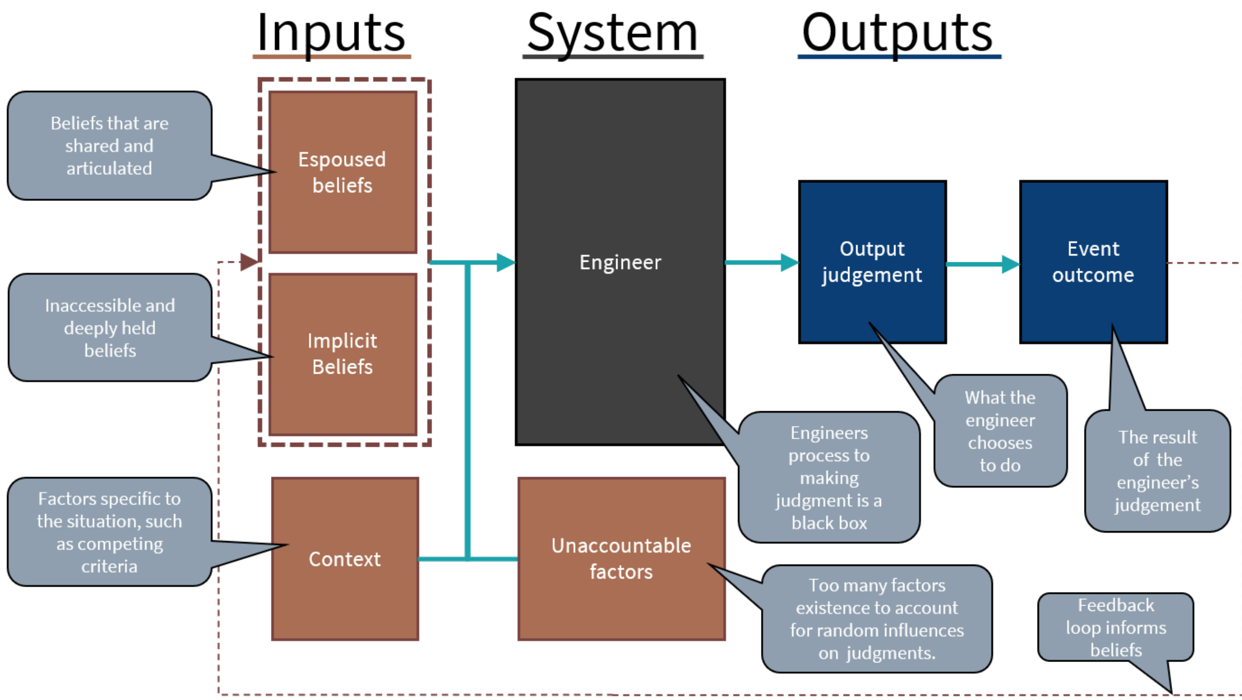

Figure 1. Conceptual model of how an engineer's beliefs contribute to their behavior.

Overall, we seek to answer the following four research questions through this project:

1) *What are engineering students' beliefs about how they would approach process safety judgments with competing criteria?*
2) *How do students react to the process of comparing their beliefs and behaviors in process safety judgments?*
3) *What gap, if any, exists between their beliefs and behavior?*
4) *How do they reconcile any gap between their beliefs and behavior?*

In the context of process safety, we are concerned about how engineers believe they approach process safety judgments in scenarios where their attention is split between competing criteria. While any of these criteria may be considered important, engineers may not always be aware of how these criteria compete for attention and resources, and thus influence their judgments. As such, we are interested in engineers' believed approach to making judgments in these situations.

Methods

We answer these four research questions through three phases of data collection and analysis: a semi-structured interview on engineering students' espoused beliefs (Beliefs Interview), students actual process safety judgments made in a simulated environment (gameplay), and a second semi-structured interview where students are shown the alignment (or lack thereof) between their espoused beliefs and their judgment-making behavior (reconciliation interview). We only describe Phase 1 here as it applies to our preliminary findings, but we provide a complete description of these phases in prior work [4].

During the Beliefs Interview, we asked a sample of 14 senior chemical engineering students to rank the aforementioned process safety criteria (e.g., leadership, production, relationships, safety, spending, time) [4]. Next, we talked through five hypothetical scenarios that directly juxtaposed two of these criteria and were asked to make a judgment. Students' espoused beliefs to the rankings and approach to scenarios were typically brief, so we asked students to then justify each choice through probing questions for each scenario. Interview recording software transcribed interviews. Researchers verified the accuracy of the interviews and generated analytic memos that summarized main points from the interviewees. Memos enabled researchers to internalize how each student believed they approached judgments. Researchers then used memos to identify emergent themes from the interviews [18] regarding how students justify their espoused beliefs. We compared themes in the transcript data and developed first order codes supported by quotes from the interview. These codes provide answers to the first research question regarding engineers' beliefs on their approach to judgments. In the process of developing the analytic memos, emergent findings on how students justify their espoused beliefs were identified that are shared here.

Preliminary Finding

We identified as part of our analysis that students frequently drew from their lived experiences to justify criteria rankings and hypothetical-scenario judgments. Lived experiences, such as coursework, internships, or retail employment provide individuals with a foundation to ground or inform their beliefs [9], [10]. Thus, students' lived experiences may be especially important as they contribute to grounding and informing students' espoused beliefs.

Specifically, we saw that students' prior experience with leadership influenced their espoused beliefs relative to the role of leadership in making process safety judgments. Students frequently recalled experiences with their mentors and managers to justify how they ranked this criterion during their Beliefs Interview. One student describes leadership as important but ranks the criterion low on the scale (fifth place) as they recall a difficult internship experience in the following quote. While prior experiences did seem to inform beliefs among other criteria, it was prominent with the leadership criterion.

> *"I do think leadership… and being able to lead your employees is very important. However, I don't think that that's as high as a lot of things on here… but then, all of a sudden it was like five seconds, we were standing on the platform. The steam came around us. That's when the incident happened. We finally got out of the*

> *steam. We got in the car to go back to the office, and I said, hey, 'I think we should write a near-miss into that report.' There's nothing. Nobody talked about it in the car, so I assumed that nobody was going to write it. So, then I went to my manager because I don't [know how to write the report], I didn't have the resources as an intern to figure out how to go and write that. So, I went to my manager the next day, and I said I was involved in the incident. I think that a near-miss report should be written, no matter what my mentor thinks about it, because it was a really scary incident, and I think people should know about it, and people should be more cautious about it. So, my manager was very supportive of me, and he was happy to help write that. So, he got with my mentor, and told her that we need to write a near miss report. You shouldn't have acted the way that you did, because safety was our number one priority, and so they did write a near* miss *incident report. So, in terms of support, I got lots of support from my manager. My mentor was not as supportive…"* -Hotel

We also saw that students would express difficulty in defining or justifying their approach to process safety judgments when they recognized they lacked applicable prior experiences. During their Beliefs Interviews, multiple students would pause and explicitly state how they recognized they lacked experience with a scenario that would impede them from being able to ascertain how they would approach the judgments presented to them. An example of this behavior is shown in the following quote from Lemon.

> *"I think. Well, okay. So, I don't have any like experience with the safety part as much kind of like, just because I never worked in a plant. But I know that like leadership. The reason why I think that's most important is just because when you have a good leadership, everything else falls into place… For example, at work, my manager is…"* -Lemon

We found that when students had relevant experience to support their criteria rankings or their responses to hypothetical scenarios, they were able to easily justify their espoused beliefs. However, a lack of relevant experience suggests that students may have implicit beliefs about how to approach process safety judgments but that these implicit beliefs are hard to justify. Implicit beliefs occur at the unconscious level, meaning we may have no memory of how those beliefs are formed [19]. Thus, the students without practical experience may have a more difficult time justifying their espoused beliefs as they may be formed implicitly. This affirms the findings in this preliminary work that relevant lived experience may be important for engineers to ground and solidify their beliefs [9].

Current Status & Future Work

We recently completed a pilot study of this project with four senior chemical engineering students during the Spring 2022 academic term [4]. Upon completing the pilot, fourteen students enrolled in a full scale study across the Fall 2022 and Spring 2023 academic terms. While analyzing transcripts from interviewing these students on their believed approach to making process safety judgments, we found preliminary evidence of the impact of lived experiences on expressing one's espoused beliefs. Future work will continue to analyze data collected across the three collection phases to provide answers to the four research questions.

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