STUDIES IN ENGINEERING EDUCATION

Dringenberg, E., et al. (2021). Student and Faculty Beliefs about Diverse Approaches to Engineering Design Decisions. *Studies in Engineering Education*, 2(2), pp. 78–95.

EMPIRICAL RESEARCH

Student and Faculty Beliefs about Diverse Approaches to Engineering Design Decisions

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Background: Engineers need to be able to make robust design decisions. Because design is an ill-structured endeavor, design decisions require some combination of rationalistic, intuitive, and empathic approaches. However, engineering education remains largely oriented towards the use of rationalistic approaches.
Purpose/Hypothesis: We posit that the persistent gap between the need to leverage diverse approaches to make engineering design decisions and the emphasis on primarily rationalistic approaches in engineering spaces is due, in part, to the beliefs that individuals hold about diverse approaches.
Design/Method: We analyzed interview transcripts to identify the beliefs shared by students and by faculty (as individual units of analysis) about rationalistic, intuitive, and empathic approaches to making engineering design decisions, and then we compared the shared beliefs of the two groups.
Results: Students and faculty similarly shared a belief that rationalistic approaches are normative in engineering. The two groups also had a common, general belief that empathic approaches are missing in engineering, but they differed in the ways in which they talked about empathic approaches. Finally, the two groups differed in their beliefs about the role of diverse approaches in practice: students believed rationalistic approaches are and should be used most in practice, but faculty believed that rationalistic approaches are inherently limited and therefore require the use of intuitive approaches.
Conclusions: We interpret the pervasive belief that engineers are expected to portray their design decision making as primarily rational as a reflection of an unrealistic yet powerful social norm in engineering spaces, which can be understood as a key part of how the exclusive culture of engineering is perpetuated. We see a need to teach explicitly about this social norm in order to disrupt it, and we encourage engineering educators to reflect on how the ways in which their praxis might endorse or reinforce such unrealistic beliefs, either explicitly or implicitly.

Keywords: decision making; capstone design; beliefs; rationalistic; intuitive; empathic

1. Introduction & Background

Design is central to engineering practice (Sheppard et al., 2008), and design is ultimately a series of decisions to be made (Akin & Lin, 1995; Strobel & Pan, 2011). The design decisions made by engineers ultimately have major implications for the safety and well-being of society (Pritchard & Baillie, 2006; Rugarcia et al., 2000). Therefore, a key piece of any engineer's development is to become an effective and responsible decision maker in the context of design. The bulk of research on decision making has historically assumed that people act rationally in order to make decisions that provide the greatest utility, and similarly, most of the work in decision making has been aimed at generating or refining techniques to aid people in making decisions rationally (Jonassen, 2012). But this normative view of decisions as solely or primarily being made using rationalistic approaches does not hold up as complete based on investigations of real-world decision making because people do not strictly follow prescriptive models when making decisions (for summary, see Jonassen, 2012).

Ultimately, engineering design decisions in real-world contexts are made in the face of ambiguity and do not possess a single correct answer, so they cannot be made using rationalistic approaches alone (Jonassen, 2000, 2012; Jonassen et al., 2006; Ullman, 2001). In addition to rationalistic approaches, engineers can also draw on intuitive and empathic approaches (see Section 3 for the details of our theoretical framework for diverse approaches to decision making as rationalistic, intuitive, and empathic). Intuition is widely recognized as an important aspect of expert design decision making (Cross, 1999; Phillips et al., 2004), and researchers have clearly documented that engineering designers use intuition throughout the design process (Baird et al., 2000; Cross, 2001; Gainsburg, 2006; Girod et al., 2003). Crismond and Adams (2012) advised that while designers should avoid framing their use of intuition as something mysterious, it is important to integrate one's inclination for some design options over others based on feelings (i.e., one's intuition) into their more analytical or rationalistic insights. More recently, Young (2018) made the argument that intuitive approaches are necessary for engineering design because rationalistic approaches are ultimately just tools to inform judgments. Additionally, empathic approaches are integral to engineering design. Scholars have established the theoretical argument that engineering design decisions require the use of empathic approaches (Gunckel & Tolbert, 2018; Walther, Miller, et al., 2017), and significant scholarship has provided an understanding of how and why to develop empathy in engineering students (Canney & Bielefeldt, 2015; Hess & Fila, 2016; Hess et al., 2019; Kouprie & Visser, 2009; Walther et al., 2016; Walther, Miller, et al., 2017).

Despite the need for diverse approaches to enable robust engineering design decisions, rationalistic approaches largely remain the focus of engineers' development. Although some structured activities offer students with the opportunity to experience ill-structured design settings (e.g., service learning, Engineers Without Borders), most undergraduate engineering curricula prioritize solving well-structured engineering science problems, which possess a single right answer and are solved with rationalistic approaches. Well-structured problems require different cognitive skills than those needed to engage with ill-structured design contexts, which are central to engineering practice and cannot be solved with rationalistic approaches alone (Agogino et al., 1992; Douglas et al., 2012; Dym et al., 2005). Engineering students are expected to engage with design at some point during their undergraduate experience (ABET, 2020; International Engineering Alliance Secretariat, 2014) and will, at a minimum, engage in a team-based design project in a capstone course (Dutson et al., 1997). However, even engineering capstone design educators primarily emphasize the use of rational tools (e.g., Pugh method) when teaching their capstone students to make design decisions (Dringenberg, Abell, et al., 2019). Students are likely introduced to the idea of empathic approaches to design decisions in the form of user or client needs, but explicit instruction about how to use empathy to leverage other perspectives is rare (Strobel et al., 2013). Relatedly, students tend to focus on technical aspects of their design decisions (Toh & Miller, 2019), and even when prompted with ethical dilemmas, engineering students justify their decisions most frequently with rationalistic reasoning (Bodnar et al., 2020). Additionally, even when design projects focus on community engagement and are rich with opportunities to practice empathic approaches directly, faculty still focus on the quantitative and technical aspects rather that the community engagement components of the work (Brewer et al., 2015). It has also been documented that engineering often overlooks and even neglects intuition and its benefits for design (Raudsepp, 1980). We view this gap between the reality that engineering design decisions require some combination of diverse approaches and the fact that engineers are mostly encouraged to develop their rationalistic decision-making abilities as problematic because the overemphasis on rationalistic approaches is likely to generate unrealistic beliefs about what engineers do and what skills or strengths are needed to contribute to the engineering profession, which contributes to the exclusionary nature of engineering (Camacho & Lord, 2013; Faulkner, 2007).

In order to better understand why a gap persists between the need for diverse approaches in engineering design decisions and the almost exclusive focus on rationalistic approaches in engineering spaces, we chose to investigate the beliefs that members of the engineering community hold about diverse approaches to decision making. We think it is important to study beliefs because they are foundational to our understanding of the world, and they inform behavior, at least to some degree (Fishbein & Ajzen, 2011; Nespor, 1987; Pajares, 1992; Rosenthal & Jacobson, 1968). Furthermore, beliefs about how and why things happen are central to human reasoning and decision making (Kuhn, 1991; Sloman & Fernbach, 2018). Ultimately, beliefs inform our conduct in real-world settings (Connors & Halligan, 2015; Saldaña, 2016; Smith, 2016). Even though some research has shown that what people say they believe does not directly align with what they do in practice (e.g., Polly & Hannafin, 2011), beliefs ultimately matter because they "shape our every response to every situation" (Smith, 2016, p. 89). Experts have already shown that designers incorporate their beliefs and cultural norms into their decision-making processes (Jonassen, 2008). Plus, beliefs are important to study because they are a foundational component of culture and professional socialization; beliefs serve as group norms and values, which are transmitted socially (Connors & Halligan, 2015; Pajares, 1992; Saldaña, 2016; Sloman & Fernbach, 2018; Smith, 2016). Specifically, we focused on the beliefs that are *shared* within two distinct units of analysis in the context of undergraduate engineering education (students and faculty) because the beliefs shared by individuals in a given context need to be understood in order to change culture more broadly (Schein, 2010). Ultimately, we are motivated to do this work because we suspect that if we were socialized to believe that engineering requires the ability to leverage diverse decision-making approaches, more diverse ways of knowing and doing would become welcome in engineering, thereby creating an opening to broaden inclusive participation in our profession.

Extant research on the beliefs that members of the engineering community do hold about diverse approaches to design decisions is limited and not well-connected. First, research related to beliefs about rational approaches has largely focused on the perceptions of undergraduate students, concluding that they believe rational approaches are central to engineering, even at the expense of other important aspects of the profession. For example, researchers have concluded that students perceive engineering as requiring technical skills, which most people assume to be rational and based on objective science (Schon, 1984), rather than skills to enable effective social engagement (Cech, 2014; Stevens et al., 2005). In one study, published almost twenty years ago, researchers specifically demonstrated that senior engineering students believed that ill-structured design is secondary, not central, to engineering practice (Downey & Lucena, 2003).

Second, research related to beliefs about intuitive approaches is almost completely missing from the literature. Within engineering education, recent efforts have been made to start a conversation about the role of intuition in engineering education (Dringenberg et al., 2019; Dringenberg, Wertz, et al., 2019), how to develop intuitive skills in students (Martin et al., 2020; Millard et al., 2007), and how to measure intuition (Miskioglu & Martin, 2019). The only research we were able to find at the time of the writing of this article that directly informs our understanding of *beliefs* about intuitive approaches was a preliminary finding that practicing engineers believe intuition is essential to their development as decision makers (Miskioglu et al., 2020).

Finally, when it comes to beliefs about empathic approaches, researchers have shown that while engineering faculty and students may acknowledge the hypothetical usefulness of empathy in engineering, they do not generally consider it fundamental to the profession. For example, researchers have documented that while students perceive empathy as potentially important for engineering, they also perceive empathic approaches as generally outside the scope of engineering work (Fila & Hess, 2016) and have difficulty understanding the connection between engineering problem solving and empathic engagement with others (Walther et al., 2020). Plus, even when students profess a belief that empathy has an important role to play in engineering, they do not translate their espoused beliefs to their actual design decisions (Guanes et al., 2021). Faculty also perceive empathy as relevant in certain aspects of engineering (e.g., teamwork and considering implications of decisions), but they consider empathy to be an add-on rather than an important skill to develop in students (Strobel et al., 2013). In fact, faculty do not define engineering in terms of empathy at all (Pawley, 2009).

In sum, while researchers have investigated the beliefs about diverse approaches to decision making held by members of the engineering community, extant work is focused on a particular approach (e.g., empathy) as well as a particular group of community members (e.g., students, faculty, or practicing engineers). In contrast, our study was designed to investigate 1) beliefs about three diverse approaches in the same context, and 2) both beliefs shared by undergraduate students and beliefs shared by faculty members with significant industry experience. By studying diverse approaches simultaneously and for each unit of analysis (students and faculty), we are able not only to synthesize beliefs about diverse forms of reasoning shared within each participant group, but also to compare the shared beliefs of students with the shared beliefs of faculty. The comparison is important in terms of making recommendations because if the beliefs that students share with one another and the beliefs that faculty share with one another are different, we can direct our attention to the ways in which undergraduate education may be disconnected from engineering practice. However, if the shared beliefs of the two groups are similar, we can direct our attention to the role of broader engineering culture.

2. Research Question

Our study addresses the following research question:

> When it comes to rationalistic, empathic, and intuitive approaches to engineering design decisions, how do the shared beliefs among students compare to the shared beliefs among faculty?

3. Theoretical Frameworks

3.1 Diverse Approaches to Design Decisions: Rationalistic, Intuitive, Empathic

The framework that we used to design and conduct this research was adopted from the patterns in informal reasoning used by undergraduate students when making sociotechnical decisions (Sadler & Zeidler, 2005). The framework was appropriate because sociotechnical decisions are similar to engineering design decisions in that they are complex and lack a single correct answer. Sadler and Zeidler's (2005) research revealed empirically that students utilized three distinct and sometimes overlapping types of reasoning when making complex decisions: rationalistic, emotive, and intuitive. Based on our previous research in this space, we replaced the term *emotive* in their original framework with the term *empathic* because of our interest in the action of having "feelings of concern for other individuals' needs" (Sadler and Zeidler, p. 115) as opposed to the emotional reactions of our participants when making design decisions. Our justification for that change has also been made in previous publications (Guanes et al., 2019; Guanes et al., 2021). We provided the following operationalizations and examples to our participants as the explicit framework for diverse approaches to decision making:

1. Rationalistic—deliberate, uses logic to weigh pros and cons, often impersonal
   Example: comparing the cost or time needed for different options
2. Intuitive—an immediate reaction to one of the options, gut-feeling, not easy to explain
   Example: having an immediate feeling that one of the choices is good or bad
3. Empathic—considering the decision from another perspective
   Example: considering the needs of the user, or maybe someone else on your design team

3.2 Beliefs as a Research Construct

Beliefs were our central research construct. For the purposes of this study, we focused on the content of our participants' beliefs (what they believed) and not the ways in which they arrive at or commit to their beliefs (why they believed it), as differentiated by Kuhn (1991). We also acknowledge that beliefs can exist at a conscious or espoused level, as well as at a subconscious level (Connors & Halligan, 2015; Smith, 2016). Our methodology of asking individuals to explicitly state their beliefs predominantly captured their espoused beliefs. However, while we assumed that beliefs can be accessed by studying what participants say out loud during an interview, our analysis focused on the beliefs that come through as coherent throughout a participant's interview, allowing us to focus on what beliefs are being conveyed more holistically. In other words, when we concluded that our participants *believed* something, we largely drew on a finding that hung together cohesively throughout their interview rather than picking out one-off comments that were not supported by the rest of their transcript. While this does not guarantee that we accessed beliefs held at a deeper level, it did avoid the risk of concluding that participants believed something that was just said once, or at a superficial level. Finally, our decision to focus on the beliefs that were shared among the student participants and among the faculty participants reflected our assumption that while beliefs are complex and can include a great deal of nuance and contradiction, by focusing on beliefs that are shared within a group, we can understand those beliefs as a reflection of the culture or subculture common among participants. For this study, we assumed that the beliefs shared by engineering students reflect the culture of undergraduate engineering education (and limited industry experience) while the beliefs shared by engineering faculty reflect the culture of engineering education as well as engineering, more broadly given their experience working in industry.

4. Researcher Positionalities

As authors, we recognize that our positionalities impact the entire research process and are especially relevant for our interpretation of the data. Beyond the first author working as an entry-level design engineer for less than one year, across the three of us, we have no experience working as engineers in industry. Our positions as academics means that we come at this research with a lens of pursuing an academically oriented understanding of the beliefs that students and faculty hold, and our interpretation of their beliefs is largely theoretical since we do not bring the lens of industry experience to our work as researchers. Some of the bias we bring to our interpretation of our data is that we have all experienced engineering culture as exclusive to diverse approaches and to us as individuals who desire to integrate diverse approaches into our own practice as engineering educators and researchers. In general, as a team, while this research was not conducted from a critical paradigm, we do we generally aim to bring a critical eye to the dominant beliefs in engineering, especially as those beliefs may be understood as functioning to maintain the oppressive status quo for participation in engineering.

5. Method

This research is qualitative in nature, which aligns with our goal of exploring and describing beliefs about diverse approaches to decision making in the context of engineering design shared among students and among faculty. Our use of a constructivist paradigm means that we assume that reality exists within the perceptions of our participants, rather than as external or objective (Magoon, 1977). This research orientation is largely accepted within educational research (Bunniss & Kelly, 2010; Poni, 2014; Taylor & Medina, 2011), and complements more traditional engineering research, which is historically conducted from a post-positivist paradigm. As such, we used the data that we collected from our participants as cases to refine our theoretical understanding of shared beliefs as a reflection of culture in engineering. We did not observe the behavior of our participants, but instead, we solicited and analyzed their descriptions of their experiences making decisions during the engineering design process and their espoused beliefs about the way that engineering design decisions are and should be made in practice. This methodological approach complements other studies, which have directly observed or characterized design behaviors (such as Ahmed et al., 2003; Atman et al., 1999; Atman et al., 2007; Baird et al., 2000; Cross et al., 1994; Cross & Cross, 1998; Reimlinger et al., 2019).

5.1 Participants

The participants for this study were recruited to represent two distinct groups of individuals: 1) engineering students at the end of their undergraduate education (i.e., seniors enrolled in a capstone design course), and 2) engineering faculty with industry experience who returned to academia after at least some industry experience and were teaching capstone design courses for undergraduate engineering students. Students were recruited from capstone courses at a single large, Midwestern university, and faculty were recruited from the 2018 Capstone Design Conference to represent a variety of institution types and disciplines. We interviewed all the students and faculty who agreed to participate in the study. The final data set was composed of interview transcripts from six engineering practitioners and ten engineering students. Our student participants provided insight across engineering disciplines, as they represented four different academic departments and one minor program in the College of Engineering: biological, biomedical, chemical, and mechanical, and engineering science. Women were overrepresented in our sample in comparison to their representation in the college and in the field, and our student participants were all white except two students who identified as South Asian. The faculty participants also represented a broad range of engineering disciplines, including computer science, mechanical, biomedical, material sciences and multidisciplinary engineering, as well as various amounts of time both in engineering practice and in teaching. However, the diversity of the sample was limited in that only men were interviewed, and all but one of those men identified as Caucasian or White. The participant tables provided in Appendices 1 and 2 provide additional details of the demographic information of our student and faculty participants, respectively. As common in qualitative research with small sample sizes, we invite the reader to examine the extent to which our participants and context are similar and different from their own students, colleagues, and contexts in order to judge to what extent our findings are transferrable to other contexts (Lather, 2007). Furthermore, we must make explicit that our faculty participants were exclusively male and predominantly White, and our student participants were predominantly White (Pawley, 2017). While this does mean that our findings about shared beliefs are likely to reflect typical engineering spaces (e.g., also overrepresented by those majority groups), it also means that our findings are limited in their transferability to minoritized groups (e.g., female engineering faculty).

5.2 Data Collection

We collected data through one-on-one, semi-structured interviews. We gave our participants the choice of either selecting a pseudonym or using their own name to identify their data. In an attempt to match the rank of the interviewer and interviewee, the student participants were interviewed by a graduate research associate (author Guanes), and the faculty participants were interviewed by a faculty member (author Dringenberg). We conducted and recorded all interviews either in person or over an online video call platform.

Due to our interest in learning about the beliefs our participants held about approaches to decision making, we utilized a retrospective approach to the creation of the interview protocol. Retrospective interviews, or interviews that ask participants to describe past situations, have been identified as useful to learn about participants' beliefs (McNeill et al., 2016; Van Gog et al., 2005). Moreover, Robinson (2014) offers that because it can be difficult to describe the exact past experience at the moment of the interview, the descriptions provided by the participant in retrospective interviews inherently become more belief-driven rather than descriptive-driven. We conducted each interview using the same interview protocol, which provided participants with definitions and examples of each of the approaches (rationalistic, intuitive, and empathic), as detailed in Section 3.1. Students were asked to answer the interview questions by talking about a decision made within the context of their capstone design experience, and faculty were asked to answer the same questions but by talking about a decision made within the context of their professional engineering design work. Briefly, our interview protocol focused on the following open-ended prompts and questions:

- I'd like to hear about an engineering design decision that you've made that stands out to you. Please describe the decision and how you made it.
- What role did rationalistic approaches play? Intuitive? Empathic?

We also asked participants to comment more explicitly on their beliefs about how engineering decisions should be made:

- Overall, how do you think engineering decisions should be made?
- What role should rationalistic approaches play? Intuitive? Empathic?

Throughout all interviews, we utilized follow-up questions to generate rich data that allowed for interpretations of the beliefs that students shared and faculty shared about diverse approaches to engineering design decisions situated within the contexts of their full transcripts.

5.3 Data Analysis

Interviews were transcribed verbatim by a professional transcription service. Transcripts were then checked for accuracy by a member of our research team and de-identified for analysis and publication purposes. Our first step was to perform first order coding (Saldaña, 2016) with students and faculty as distinct units of analysis to generate codes for all the distinct beliefs conveyed about each approach to decision making. For students and faculty separately, we utilized initial and in vivo coding (Saldaña, 2016) to perform data condensation (Miles et al., 2014). Initial coding refers to the process of breaking down the data into parts while following "general guidelines" (Saldaña, 2016, p. 115). We used the theoretical framing of diverse approaches (rationalistic, intuitive, and empathic) to perform our initial coding by looking for instances of beliefs about each approach explicitly. In vivo coding (Saldaña, 2016) was used in cases where we felt that maintaining the distinct language of the participants was relevant. In terms of process, two members of the research team (authors Dringenberg and Guanes) individually coded a subset of the interview transcripts, and then we compared our coding schemes, discussed our codes, and used the whole transcript to justify our coding decisions to one another. Throughout this process, we used a constant comparative technique to understand the codes within individual transcripts and between transcripts for each unit of analysis to ensure that our findings are well-supported by our data (Boeije, 2002). This iterative analysis process was used on remaining transcripts until we converged on a final codebook for students and a final codebook for faculty. From there, we performed second order, axial coding (Saldaña, 2016) on each codebook as a form of data display techniques (Miles et al., 2014) to pull together the cohesive story of shared beliefs by integrating and characterizing the relationships between the codes in the codebook, which resulted in our understanding of the shared beliefs of students and the shared beliefs of faculty. Finally, we compared these shared beliefs between the two units of analysis to answer our research question.

5.4 Research Quality

We made efforts to build quality into the ways in which we made and handled data during this study (Walther, Sochacka, et al., 2017). In terms of making the data, the interviews for each unit of analysis (students and faculty) were conducted by the same member of the research team (Guanes and Dringenberg, respectively), which contributes to process reliability. Additionally, communicative validation was built into the interview protocol process by providing participants with definitions and examples of the three decision-making approaches under investigation. In terms of handling the data, to strengthen the trustworthiness of the study (Creswell & Miller, 2000), we made deliberate decisions about what counted as a belief at each step of the qualitative data analysis. For example, two of the authors (Guanes and Dringenberg) held weekly meetings over several months to compare our individual coding efforts, discuss at length, iterate, and arrive at a consensus on how to meaningfully capture our participants' beliefs about diverse approaches to engineering design decision making. For example, we would ask ourselves, "What is this participant saying about [rationalistic/intuitive/empathic] approaches, and how does this relate to the rest of the interview transcript in terms of their beliefs? What evidence do we have that they believe it?" Additionally, we leveraged the constant comparative technique (Boeije, 2002) to systematically make sense of our participants' data as individual transcripts as well as in terms of synthesis within units of analysis (students and faculty). To strengthen the theoretical and communicative validation of our data analysis (Walther, Sochacka, et al., 2017), we presented the codebook development to other engineering education researchers whose expertise were related to beliefs and engineering design and whose perspectives complimented the positionalities of our research team. Our colleagues provided feedback on the data analysis process and their thoughts on how to make sense of the qualitative data.

6. Findings

In this section, we detail the findings from our second order data analysis comparing the shared beliefs of students to the shared beliefs of faculty about rationalistic, intuitive, and empathic approaches to making engineering design decisions. To reiterate, our methodological approach was to generate findings about beliefs, iteratively and collaboratively, based on what participants said explicitly, interpreted within the context of their entire interview transcript. However, for illustration purposes, our findings are presented in this section with individual quotes serving as evidence. It should be noted that the selected quotes are meant to serve as exemplars of beliefs that were conveyed more broadly by participants.

6.1 Students and Faculty Were Similar in Their Shared Belief That Rationalistic Approaches Are Normative in Engineering

Our first finding is that students and faculty were similar in that they both held the shared belief that rationalistic approaches are normative in engineering, meaning that rationalistic approaches are valued and expected as the way to make and justify engineering decisions. Evidence for this interpretation of students' beliefs includes their descriptions of rationalistic approaches as all they experienced during their undergraduate training.

> "It really is the rational, like crank out the work, the calculations, do all that stuff and then cater it or make it look pretty… it's mainly how I see it." — Anna, student

Students also conveyed their belief that rationalistic approaches are normative in engineering by expressing their understanding that other approaches (here, intuitive) are viewed as inadequate justification for engineering design decisions; they believed that even if they used other approaches (e.g., intuitive), they are expected to portray their decisions as rational.

> "I think the rational is very pounded hard on all engineers, like make sure you're thinking through something rationally, you're looking at the numbers and we're all very number-oriented people. So, I think it's encouraged. I think, intuitive is kind of frowned upon in the engineering world." — Felicia, student

> "I think intuitive is one of the harder ones [to use] because you want to be able to justify something rationally."— Felicia, student

On the faculty side, the belief that rationalistic approaches are normative in engineering was demonstrated by participants' descriptions of the social pressure they feel as engineering faculty members to portray their design decisions as made rationally. Our participants expressed that they are expected to be guided by rationalistic approaches above all else, or else face social judgement.

> "I would say… in engineering faculty, if you don't do rational decision making or don't place rational decision making, honestly, first, you're probably gonna hear about it. I mean, it's something that's gonna bubble up in conversation. It's generally expected that as an engineer faculty, rationale and intuition, but to a greater degree rationale, is what ought to be the guiding principle in decision making."— TJ, faculty

> "I feel like we have filtered that out of our mindset. Engineering is logical. Engineering is science, and engineering and science are not intuitive. They are rational-based studies and interactions, if you will… Eventually, it becomes socially unacceptable to say that it's anything else other than a rational decision, because the idea is you should always make a rational decision." — Enrique, faculty

Faculty emphasized that while engineers may use other approaches in their actual decisions, the use of those approaches is never made explicit due to the social norms in engineering, which condone anything that is perceived as non-rational or associated with feelings.

> "Uh … I think people naturally do [use empathic approaches to engineering design decisions], whether they express it or not […] I think within an engineering world, um, [empathic approaches are] typically not accepted. Like the old term, 'There's no crying in baseball.'" — Fred, faculty

> "So … between rational, intuitive, and empathy—the latter two must be carefully packaged in terms of engineering judgement… There's this song and dance that you have to do around it. I mean, at a very, very high level, where this comes into play is if it… I know for a fact if I walk into a room full of design faculty and say, 'Engineering design is both science and art' the looks I will get, the pushback is immense. 'What do you mean by art?… All of the decisions we make are founded in and rooted in logical analysis.'" — Enrique, faculty

The fact that both students and faculty members held a commonly shared belief that rationalistic approaches are what is socially acceptable in engineering demonstrates the extent to which the broader culture of engineering requires the performance of rationality in a very salient way. Because this belief was pervasive across both units of analysis, we interpret this idea of the pressure to portray your decision making as rational as a reflection of engineering culture broadly.

6.2 Students and Faculty Differed in Their Shared Beliefs about the Role of Diverse Approaches in Real-World Engineering Design Decisions

While faculty and students both believed that rationalistic approaches are emphasized and expected (normative) above both intuitive and empathic decision-making approaches in engineering, they differed in their beliefs about which approaches are central to actually making engineering design decisions in practice. Students believed that rationalistic approaches are (and should be) central to engineering decision making and that intuitive or empathic approaches may play a supplementary role in some instances. In contrast, faculty believed that rationalistic approaches are inherently limited and are therefore always used in combination with intuitive approaches when making engineering design decisions. In other words, students believed that intuitive and empathic approaches can be used to supplement rationalistic approaches within certain contexts, and faculty defined rationalistic approaches as inherently limited and therefore requiring intuition.

Our assertion that students shared a belief that rationalistic approaches are and should be used the most to make real-world engineering design decisions is supported by the ways in which they talked about their own experiences completing an engineering capstone design project. For example, many students conveyed a belief that during their project, "the majority of decisions are made rationally." Even when students acknowledged that other approaches are sometimes used when making engineering design decisions, they described the role of other approaches as "behind the rational reasoning." Students' belief that rationalistic approaches are central to engineering design decisions was also supported by the synthesis of their beliefs that rationalistic approaches were used throughout many phases of their design process. Students described the use of rationalistic approaches across all phases of the design process: to generate initial options, to think about the engineering constraints, to gather information, to evaluate design options by going through "pros and cons" lists, and to justify and to get others to *see* why they made such a decision. Students further demonstrated their belief that rationalistic approaches are central to making engineering design decisions via their descriptions of how they believe engineering decisions should be made in practice; while they acknowledged that other approaches may play a complementary or supportive role in some instances, they emphasized rational as the most important.

> "I think [engineers] should definitely use all three [approaches]. Mostly, obviously, leaning mostly on the rational reasoning." — Brian, student

> "I think that the first step should pretty much always be rational. Just to break it down into like smaller parts. However, I think it should be complemented by empathic and intuition. Because there could be other pieces to the puzzle and other perspectives that you kind of need to make a good decision." — Darcy, student

When describing the role intuitive approaches play for engineering decisions, students constrained the use of intuitive approaches to particular situations, such as when one is out of time or making less consequential design decisions.

> "Sometimes you might not… you might have to do extensive amount of logic or reasoning to reach a decision. But sometimes you don't have that time or that luxury that you kinda just have to go with your gut feeling on one." — Grace, student

> "I think with going between a couple of similar decisions, intuition can be helpful because if you just have a feeling something isn't going to work, it can help eliminate that decision."— Darcy, student

In contrast, faculty members shared a belief that rationalistic approaches are fundamentally limited and can only "get you so far." Their belief in the inherent limitations of rationalistic approaches was often attributed to how much information is available to make design decisions or the complexity of the decision at stake. To faculty members, rationalistic approaches were described as a "baseline," used in engineering practice for basic tasks such as testing specifications (e.g., go–no go verifications). Thus, beyond rationalistic approaches, intuitive approaches have to be used to make actual design decisions, or judgements.

> "Even though it seems like they should be technical decisions, there should be all kinds of facts laid out, it's so complex. It's just not that straight forward. In fact, the engineering in my opinion becomes a, a given. No one ever… I try to tell my students this as well. No one ever came to be me and said, 'Oh, gee, I don't know if you got the engineering right.' […] So, I'm going to hate to say this, but the engineering kind of becomes just the foundation, starting point, that's your price of entry, and then the important decisions start to get made." — Fred, faculty

> "Engineers aren't making all their decisions off of strict, logical, systematic analysis of problems. They're learning as much as they can about the problem and taking that learning and assessing it structurally the best they can and then they make a decision."— Enrique, faculty

Additionally, faculty even conveyed the belief that rationalistic tools themselves are not strictly rational in the sense that the use of those tools draws on their prior experience and therefore integrate intuitive approaches.

> "It's folly, I think, to say, 'I used these design tools, and they tell me the decision to make.' There's a level of prior experience that's informing even what I put into those tools. There's a level of prior experience that's affecting my interpretation of what comes out of those tools." — TJ, faculty

We were intrigued to learn that even though faculty members conveyed a belief that rationalistic approaches are limited, their perception of the social norm to perform rationality seemed to drive their interactions with students. Furthermore, the normalization of rationalistic approaches within undergraduate engineering education can be seen as contributing to students' different beliefs about what approaches are realistically used to make engineering decisions.

6.3 Students and Faculty Were Similar in Their Shared Belief That Empathic Approaches Are Missing from Engineering, but They Did Differ in Their Focus

Students and faculty were similar in that they both expressed a shared belief that empathic approaches are missing in engineering, but they differed in the focus of how they described their perception of a lack of empathy. Students were often quick to state the importance of empathic approaches for engineering design decisions broadly.

> "I feel like if engineers thought more about people with varying needs, then their products would be better suited towards a wider variety of people. […] I think that a lot of engineers need to focus more on adding in empathic reasoning because it plays a part." — Felicia, student

However, in their descriptions of empathic approaches, what also came through was a shared frustration or disappointment with the lack of empathy. For example, students stated that "engineers wait too long to put the client into perspective," and "engineers are really bad at seeing stuff from other people's perspectives." The following quote demonstrates how students articulate a set of complex and related beliefs about how empathy is situated in the field of engineering, in engineering education, and in engineers themselves.

> "I think it's just, we have a lot of dichotomy with engineering, like hard science, like math, stuff like that. [...] and then there's the social sciences, which are more empathic generally. I feel like there's a really strong divide. People are like, 'Oh, I'm super rational. I'm an engineer.' [...] There's a lot of training where they try to make engineers... Like, we have to take an ethics course because and people complain about it. Like, I complain about it. I'm taking it right now, and it's, like, really boring. But it's good because some people within the major don't know that stuff (laughs). Like, they don't have, like, a strong moral or ethical code because they're, like, really, hyper focused on, like, rational thought rather than, like, empathic thought." — Isabella, student

Faculty also conveyed a shared belief that engineering spaces lack adequate emphasis on empathic approaches, but their focus was on why they believed that empathic approaches are missing in engineering education and in engineering practice. In regard to education, two primary reasons emerged from our conversations with faculty, the first being that empathic approaches are difficult to teach. When talking about the difficulties of teaching empathic approaches, faculty mentioned that they are "not always like the checkbox of criteria with some numbers," that they "don't have enough in [their] own toolbox" to teach them, or that they, themselves, are "a product of what [they]'ve been exposed to," in regard to empathic approaches. The second reason focused more on the constraints that faculty had in the classroom; faculty expressed a belief that the prioritization and emphasis on rationalistic approaches within program outcomes leave no room to teach empathic approaches within engineering education.

> "It's like, okay that's just rational to the T, and we're checking boxes, meanwhile, we don't teach empathy. And it's not even in the list. Well, but don't tell me about it, because that's not rational, right? I got a list I get from [company], I check the boxes, everything's cool, everything's copacetic. We have a good program because by definition, if you could check all the boxes, you have a good program. Meanwhile, you don't teach empathy. Hello! Can we fit [empathic approaches] in? I can't, because all the boxes are filled." — Fred, faculty

Faculty also shared the belief that empathic approaches are missing from engineering practice and justified by explaining that leveraging the perspectives of others is difficult and may even be ill-advised. Faculty expressed that customers' feedback is not always the "greatest input" to make engineering decisions and "they can send you down the wrong path." Another justification as to why empathic approaches are missing in engineering practice was that, from a profit perspective, using empathic approaches to protect clients or the environment "doesn't pay," and that if empathic approaches are included in practice, it is strictly to understand the customer in order to generate profit.

> "So, the empathy part is, I think, completely missing in the automotive industry. Um, it's just not thought of, it's not brought to bear. I did say though, we do think about the customers. Um, but not in this perspective of, 'Hm, I wonder if the customer will be happy or not?' The perspective of, 'Will customers buy it? and, Are we going to extract money from your wallets?'"— Fred, faculty

7. Discussion

In general, our findings about the beliefs that students and faculty hold about diverse approaches to decision making corroborate the findings of previous research. Our finding that students believed rationalistic approaches are and should be used most when making engineering design decisions aligns with previous work that has documented student perceptions that engineering work is a rational endeavor above all else (Brewer et al., 2015; Cech, 2014; Fila & Hess, 2016). Our finding that faculty believed intuitive approaches are required to make engineering design decisions extends and further establishes the extant preliminary finding that practicing engineers say that intuitive expertise was key to their development as decision makers (Miskioglu et al., 2020). Our finding that students and faculty were similar in their belief that empathy is missing from engineering maps to prior research that demonstrated that both faculty and students see empathic approaches as hypothetically useful (Guanes et al., 2021; Strobel et al., 2013). Our finding that faculty focused on the difficulty of integrating them in real-world engineering design decisions and teaching them in the context of capstone extends upon previous work that demonstrated that while seen as a useful add-on, faculty don't prioritize the development of empathy skills in their students (Strobel et al., 2013). Our finding that students emphasize the importance of empathic approaches aligns with prior work that demonstrated that students believe empathic approaches should play a larger role, although it is important to note that belief does not equate to behavior (Guanes et al., 2021; Walther et al., 2020). Beyond these close connections to extant literature, we offer a broader discussion in the next three subsections.

7.1 Pervasive Belief That Rationalistic Approaches Are Normative in Engineering: Connections to Culture, Social Norms, and Hidden Curriculum

The commonly shared belief of students and of faculty that rationalistic approaches are normative in engineering aligns with what we understand about engineering culture. The culture of engineering as rational or technical and as masculine is well-established (e.g., Addis, 1990; de Pillis & de Pillis, 2008; Faulkner, 2007; Picon, 2004). Rationality has been central to the historical development of the profession: "rational intellectual thinking and abstract reasoning have symbolically formed the ideal of the engineer" (Holth, 2014, p. 100). Our finding that everyone shared and understanding that rationalistic approaches are what is expected in engineering spaces also maps to engineering being built on an ideology of *depoliticization,* or the belief that engineering is strictly a *technical* space, and that social or political issues are outside the scope of the function of the engineering as a profession (Cech, 2013).

This finding reveals a specific way in which the normalization of rationalistic approaches is maintained in engineering spaces: via social norms. Social norms are essentially what people in a group believe to be a typical or acceptable action; they are held in place by the expectations of those in the group (Cialdini & Trost, 1998; Mackie et al., 2015). Specifically, social norms have to do with one's beliefs about what others in the group do and what others in the group approve of and expect (Mackie et al., 2015). Extensive work by other scholars has already identified beliefs about social norms as a key belief to predict human behavior; beliefs about how socially acceptable a given behavior is has been shown empirically to function as one of the three most important beliefs that predict behavior (Fishbein & Ajzen, 2011). Furthermore, significant scholarship has demonstrated that identifying with a social group operates as a psychological state in the individual and confers a shared representation of how one should behave (Abrams & Hogg, 1990). The established power of social norms maps to our finding because whether or not an engineer portrays their design decision as a result of using a particular approach is likely to depend considerably on what they believe about 1) how other engineers portray their decision-making approach and 2) how other engineers want them to or expect them to portray their decision-making approach, neither of which are necessarily rooted in the reality of how engineering design decisions were actually made. We suspect that if engineers and engineering students believe that others are using mostly rational approaches or expect them to justify their decisions with rational approaches, it is likely that they will behave (or portray their behavior) accordingly in order to gain social acceptance. Indeed, it has been documented that engineers (inaccurately) portray their final designs as though they were the result of logical and rational processes (Gainsburg et al., 2016). While the social norms around rationality may contribute to the perceived prestige of engineering, they can also function to minoritize those who belong to groups not recognized as rational (e.g., women) (Faulkner, 2007) or individuals who seek professional development beyond technical skills (Stevens et al., 2005). The presence of social norms in engineering that prioritize rationalistic approaches is also likely related to the fact that rationality is highly correlated with perceptions of occupational prestige (Suchner & More, 1975); others have demonstrated that students believe engineering is superior to all other majors (Stevens et al., 2007). Ultimately, we think our finding supports the claim that efforts to change human behavior (e.g., getting engineers to more fully integrate empathic approaches in their design decisions) requires change in the social norms surrounding that behavior (Cialdini et al., 1990; Paluck & Shepherd, 2012).

In the landscape of education research, our identification of the pervasive belief that rationalistic approaches are normative in engineering has strong ties to the well-established concept of a hidden curriculum. The concept of hidden curriculum is attributed to Philip W. Jackson (1968), who established that education within the context of school is a socialization process that goes beyond the stated or explicit curriculum. In other words, the hidden curriculum consists of the things, including attitudes, values, and beliefs that students learn implicitly via their experience of attending school. Recently, scholars have called for additional work on the relatively unexplored concept of hidden curriculum within the context of engineering education, especially as it may operate to exclude minoritized groups in engineering (Villanueva et al., 2018). Previous work has documented the ways in which masculinity is produced and reproduced by the hidden curriculum in engineering (Erickson, 2007; Pehlivanli-Kadayifci, 2019). Specifically, an emphasis on the value of masculine thinking, which includes rational problem solving, has been established as a key part of the hidden curriculum of introductory college courses in STEM (Bejerano & Bartosh, 2015). Based on our findings, we posit that a related and important part of the hidden curriculum of engineering education systems manifests as social pressure to portray engineering design decisions as made rationally despite the reality that additional approaches are necessary.

7.2 Different Beliefs About the Role of Diverse Approaches in Real-World Engineering Design Decisions: School to Work Gap

The difference in the shared beliefs of students and of faculty about the role of diverse approaches in engineering practice reinforces what others have previously identified as a gap between the experience of undergraduate engineering education and the realities of the engineering workplace (Douglas et al., 2012; Sheppard et al., 2008). While our data does not allow us to make claims about cause, we suspect that this difference in beliefs is, to some degree, a function of the difference in work experience between the students and faculty participants. It takes guidance and experience to effectively leverage intuition when making decisions (Klein, 2017; Zsambok & Klein, 2014). We find that faculty's recognition of the use of intuitive approaches maps to well-established literature on decision making, which acknowledges that in reality, people mostly use their intuition as opposed to structured and rational approaches (Kahneman, 2011) and that people may even just use rational approaches to justify their intuitive decisions (Haidt, 2012). On the other hand, to engineering students this version of reality seems hidden, perhaps because they lack much real-world experience or extensive exposure to ill-structured decision making in their undergraduate education. We know that the educational experience plays a large role in students' formation of beliefs about what engineering is and what occurs in engineering practice (Jocuns et al., 2008). Broadly, we also know that we must rely on stereotypes to understand how the world works when we don't have any experience (Steele, 2011). We posit that the undergraduate experience, coupled with stereotypes about engineers, may lead students to believe that rationalistic approaches should be the dominant approach in engineering decisionmaking.

7.3 Differences in the Shared Belief that Empathy is Missing from Engineering

While both students and faculty expressed a belief that empathy is missing from engineering, they focused on different aspects of the lack of empathy; students focused on their frustration with the lack of empathy in engineering and engineering education whereas faculty focused on justifying why empathy is missing based on their experience. We first relate this finding to the evolution of expectations for engineering students' professional ways of being. For example, ABET's criteria includes accountability for engineers to "recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts" (ABET 2020, p. 5). Engineering programs often include ethics courses, and conversations about the role engineers play in society, at least in terms of their contributions, are encouraged in engineering spaces (National Academy of Engineering, 2008). When comparing engineering graduates of 1994 and 2004 cohorts, the more recent graduates demonstrated more awareness about societal and global issues, and more awareness of ethics and professionalism than their predecessors (Lattuca et al., 2006). Explicit conversations about the role that engineers play in society are important in the process of developing empathy in engineering students (Walther et al., 2017), so the fact that students and faculty were similar in their shared belief that empathy is missing in education may reflect the current reality that aspects of empathy (even if it isn't called that explicitly) have long been and continue to be a part of the professional expectations in engineering.

8. Limitations

We recognize that there are limitations inherent to how we approached and executed our study. First, while the framework we used to collect data allowed us to capture our participants' beliefs on diverse approaches to design decisions, the framework itself is value-laden for the context of engineering. Specifically, the word *rationalistic* is highly emphasized throughout the engineering curriculum and potentially caused students to state that their design process was based upon rational thought because of the pressure to tell us what they think we want to hear. Next, our interview protocol used the word *reasoning* instead of *approaches* as we do in this manuscript. The use of *reasoning* could have suggested that there has to be explicit reasoning behind every decision made and may, therefore, bias participants towards describing the use of rationalistic approaches. Additionally, there is a limitation in that our participants were largely homogenous in terms of race and gender. Our faculty population was exclusively men and almost exclusively Caucasian/White men. Despite our recruiting efforts, we were unable to secure any female faculty who taught capstone design to participate in the study. While our student participants do represent different majors and first-generation statuses, our student participant pool were also majority White/Caucasian, women were overrepresented, and not all engineering disciplines are represented. This directly limits the transferability of our findings. Finally, we also recognize that our choice to sample only faculty with prior experience working in engineering industry may impact the transferability of our results as not all engineering faculty have had industry experience prior to their academic appointments.

9. Recommendations & Future Work

Because one of our major findings was that students and faculty believe there is social pressure perform rationality, we offer the recommendation of making space within engineers' professional socialization to teach explicitly about the social norms, culture, and hidden curriculum in engineering and the ways in which they deny the complexity of engineering design decisions and also minoritize members of social groups who are culturally stereotyped as non-rational. This recommendation echoes Cech's (2013) argument that we must make cultural space to teach about the history and related ideologies of engineering culture and socialization in order to enable awareness and disruption of the status quo. Specifically, we believe that engineering education should explicitly teach about diverse approaches to design decisions and their social construction (e.g., social norms, ideologies) as a way for empathic and intuitive approaches to be recognized socially as legitimate in engineering.

Because we found that faculty perform rationality despite their work experience convincing them that rationalistic approaches are inherently limited, we offer a second recommendation targeted at faculty. Engineering faculty, especially those teaching design, can be considered social referents (or people with influence), and therefore have potential to change the social norms in a given context (Prentice & Paluck, 2020). We encourage faculty to reflect on their own beliefs about diverse approaches to engineering design decisions as well as the ways in which they may convey (explicitly or implicitly) related beliefs in their interactions with their peers and their students. One specific way to challenge the current cultural norms within classrooms is to consider and apply the "Engineering for Social Justice" criteria that Leydens and Lucena (2018) provided as a way to expand our ways of thinking and approaching design contributions. Beyond asking individual faculty to reflect and challenge norms in their classroom, change literature supports that such an effort would be more successful if supported through facilitators (internal or external) or through the creation of capstone faculty working groups (Henderson et al., 2011). Faculty need to feel motivated and capable of integrating their experiences with the use of diverse approaches in engineering practice, especially the experiences that led them to have beliefs that are different than their students. Of course, faculty don't function in a vacuum, so while they have some agency to alter their classroom practices (e.g., discussions they have with students, means of assessing and rewarding students), our recommendations for faculty also point to the need for parallel and cooperative changes in terms of support from administration, faculty professional development, reward structures for faculty, and other mechanisms known to foster change (e.g., Finelli & Froyd, 2019; Henderson et al., 2011). Future research might investigate the ways in which curricular or pedagogical changes actually relate to or influence student beliefs or how beliefs change as engineers transition from school to the workplace. Plus, a study with more diverse participants could bring attention to the ways in which shared beliefs may vary with different demographic groups or sets of lived experiences and positionalities. Finally, a focus on nuanced variation in beliefs would also be a helpful contribution to better understand the ways in which individuals navigate their own experiences with agency (Holland et al., 1998), as that would contrast our focus on the shared beliefs as a reflection of dominant culture.

10. Conclusion

Engineers make design decisions that have non-trivial implications for the rest of society. Because design is ill-structured, design decisions require diverse approaches, yet engineering formation remains almost exclusively on developing engineers' ability to leverage rationalistic approaches. We contributed to understanding the beliefs that, in part, contribute to this disconnect between engineering work and school. We found that engineering students and faculty with industry experience were similar in their shared belief that rationalistic approaches are encouraged and expected in engineering, which we interpret as a reflection of the powerful social norms at work in culture to portray engineering as an *objective* or strictly *technical* field. In contrast, we found that students and faculty differ in their beliefs about the role of diverse approaches in actual engineering design decisions. Finally, we found that students and faculty were similar in their shared belief that empathic approaches are missing from engineering spaces although the ways in which they conveyed this belief had different foci. We emphasize the ways in which beliefs about what is socially acceptable in engineering (rationalistic) seem to obfuscate any beliefs about the value of empathic and intuitive approaches in engineering. In conclusion, we offer the following for members of the engineering community to consider: What are the costs and benefits of normalizing the belief that engineering decisions must be portrayed as being made using rationalistic approaches alone? How might our own engineering praxis reinforce or perpetuate unrealistic beliefs about the ways of thinking and deciding needed in engineering, and what are the implications of this for maintaining the inequitable status quo of participation in our field?

Appendix

Appendix 1: Demographic information of our student participants.

Pseudonym	Sex	Race	First-generation Student	Discipline (Major)
Anna	Female	Caucasian or White	No	Mechanical Engineering
Brian	Male	Caucasian or White	No	Chemical Engineering
Carlton	Male	Caucasian or White	No	Information Systems, minor in Engineering Science
Darcy	Female	Caucasian or White	Yes	Biomedical Engineering
Elfrieda	Female	Caucasian or White	No	Biomedical Engineering
Felicia	Female	Caucasian or White	No	Mechanical Engineering
Grace	Female	Caucasian or White	Yes	Mechanical Engineering
Heather	Female	South Asian (e.g., Indian, Pakistani, Bangladeshi, Sri Lankan, etc.)	Yes	Biological Engineering
Isabella	Female	Caucasian or White	No	Biomedical Engineering
James	Male	South Asian (e.g., Indian, Pakistani, Bangladeshi, Sri Lankan, etc.)	No	Mechanical Engineering

Appendix 2: Demographic information of our faculty participants.

Name/ Pseudonym	Sex	Race	Type of Institution	Time in Industry	Time Teaching Capstone Design	Discipline
Brian	Male	Caucasian/White	large, public, research-intensive	>9 years	<= 6 academic semesters	Computer Science
David	Male	Caucasian/White	small, public, research-intensive, teaching-focused,	>9 years	> 6 academic semesters	Multidisciplinary
Enrique	Male	African American/Black	large, public, research-intensive	>9 years	<= 6 academic semesters	Mechanical
Fred	Male	Caucasian/White	small, private, teaching-focused	>14 years	> 6 academic semesters	Biomedical, Mechanical, Multidisciplinary
Jan	Male	Caucasian/White	large, public, research-intensive	>9 years	> 6 academic semesters	Materials Science, Mechanical
TJ	Male	Caucasian/White	large, public, research-intensive, teaching-focused	>6 years	> 6 academic semesters	Mechanical

Data Accessibility Statements

The de-identified data generated and analyzed during the current study are available from the corresponding author on reasonable request.

Ethics and Consent

This study was conducted in accordance with protocols #2019E0040 for the student data and #2018E0355 for the faculty data, as approved via theBuckIRB system, managed by the Institutional Review Board office at The Ohio State University.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. [1763357]. 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. We would also like to acknowledge the contributions of our participants and of the reviewers whose feedback helped us improve this manuscript.

Competing Interests

The authors have no competing interests to declare.

Author Contributions

Author 1 (Dringenberg) designed and secured funding for the overarching research project. She collected the faculty data, collaborated on analysis, and lead the conceptualization and writing of the manuscript. Author 2 (Guanes) lead the implementation of the overarching research project and collected the student data. Author 3 (Leonard) and author 2 (Guanes) both collaborated on the analysis and the conceptualization and writing of the manuscript.

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How to cite this article: Dringenberg, E., Guanes, G., & Leonard, A. (2021). Student and Faculty Beliefs about Diverse Approaches to Engineering Design Decisions. *Studies in Engineering Education*, 2(2), pp. 78–95.

Submitted: 11 January 2021 **Accepted:** 01 September 2021 **Published:** 28 October 2021

VIRGINIA TECH. | VT Publishing

Studies in Engineering Education is a peer-reviewed open access journal published by VT Publishing.

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