Understanding ethical decision-making in design

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Abstract

Background: Little is known about how students engage in ethical decision-making, especially when designing in messy, real-life contexts. To prepare ethically competent engineers, educators need a richer understanding of students’ ethical decision-making throughout the course of the design process.

Purpose/Hypothesis: This study examines students’ intuitive ethical decision-making as it emerges throughout the design process as well as when and how students engage in ethical reflection. Outlining these processes enables educators to better structure and support students’ ethical reasoning.

Design/Method: We conducted 103 semi-structured interviews with students in a multidisciplinary service-learning program. To capture how ethical decision-making unfolded over time, we sampled 13 students who had participated for multiple semesters on the same projects. The resulting 30 interviews were transcribed, coded, and thematically analyzed. We then explicated when and how students appeared to grapple with the ethical principles of beneficence, nonmaleficence, autonomy, and justice.

Results: The findings trace which ethical principles emerged as salient in each phase of the design process as well as what conditions and activities stimulated students’ reflection on their ethical decision-making.

Conclusions: Although certain phases of the design process appear to prompt consideration of specific principles, students’ interactions with users and project partners appeared to stimulate the most reflection on their ethical decision-making. We discuss how educators can leverage these and other reflection triggers to better structure and support students’ ethical reasoning as well as strategies for making intuitive processes more explicit.

KEYWORDS

design process, ethics, qualitative, reflection, reflexive principlism

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1 | INTRODUCTION

Despite increasing emphasis on developing ethically competent engineering students (Hess & Fore, 2017), few studies portray how students engage in ethical decision-making, especially as it changes throughout the course of the design process. Even fewer have examined ethical decision-making within authentic design contexts, wherein students navigate the messy interconnections between user needs, team dynamics, technical problems, and ethical issues. To prepare engineers capable of grappling with these ethical complexities, educators need a richer understanding of how students engage in ethical decision-making. Drawing on a case study of students in an undergraduate service-learning engineering course, this study uses reflexive principlism as an analytical framework to examine students' intuitive ethical decision-making and reflection, tracing how these processes shift throughout the course of the design process.

We first review the existing literature and describe our analytical lens. We then discuss the project contexts, outline the research questions, and overview the methods for this study. The findings are structured according to the design process used by the service-learning course. We conclude the article by discussing implications for engineering educators.

2 | LITERATURE REVIEW

Design is inherently social, as engineers’ moral values, beliefs, and social practices (e.g., Bucciarelli, 2008) infuse all aspects of the process. In this way, engineers’ “ethical values and decisions are woven into the fabric of everyday life” (Tuana, 2007, p. 156), producing design products laden with ethical implications (Van de Poel & Verbeek, 2006). Similarly, Zhu and Jesiek (2016) argue that ethical decision-making is a “situated practice rather than a decontextualized form of practice” (p. 667). Therefore, to understand and ultimately develop engineers’ ethical reasoning as they engage in design, one must examine “the dynamics of the design process itself and identify the ethical aspects or questions arising in this context” (Van de Poel & Verbeek, 2006, p. 225). This article examines the dynamics of the design process and how students’ intuitive ethical decision-making emerges within its phases.

We also examine what conditions or activities prompt students’ reflection on their ethical decision-making as ethical reflection supports the development of ethical reasoning skills (Beever & Brightman, 2016; Turms, Sattler, Yasuhara, Borgford-Parnell, & Atman, 2014; Walther, Sochacka, & Kellam, 2011). When engineers make design decisions, they often engage in an intuitive ethical decision-making process, drawing on their own moral values as well as the ethical expectations and standards of the engineering profession or program. However, reflecting on this intuitive ethical decision-making process builds engineers’ ethical reasoning skills, especially when educators structure and support this process (Beever & Brightman, 2016). For example, moral sensitivity, or “awareness of how our actions affect other people” (Tuana, 2007, p. 158), is necessary for developing ethical sensitivity. Ethical sensitivity combines one’s moral awareness with an understanding of “the regulations, codes and norms of one’s profession, and recognising when they apply” (Bebeau, 2002, p. 283) and is, therefore, fundamental for developing ethical reasoning (Bebeau, 2002; Tuana, 2007; Walther et al., 2011). As Tuana (2007) argues, “If our students cannot determine whether or not a situation involves an ethical issue or weigh the moral intensity of the issue, they will not be able to react responsibly” (p. 369). Thus, for students to move from moral sensitivity to ethical sensitivity, they must reflect on their implicit moral values and understandings of ethics. This reflective process and the importance of ethical reflection generally align with the principles of value-sensitive design (Friedman, 1996) and reflective design (Sengers, Boehner, David, & Kaye, 2005), in which designers are taught to reflect on the values that infuse their engineering products and consider their ethical implications.

This article aims to make explicit students’ often implicit moral and ethical decision-making processes, such that educators can observe which ethical principles emerge as salient in various stages of the design process as well as what conditions facilitate students’ reflection on their decision-making. Thus, we argue that explicating students’ intuitive ethical decision-making and reflection enables educators to better develop students’ ethical sensitivity, reflectivity, and their overall ethical reasoning.

2.1 | Analytical lens: Reflexive principlism

To examine students’ ethical decision-making, we draw on Beever and Brightman’s (2016) framework of reflexive principlism, an emerging heuristic for engineering ethics (e.g., Hess, Beever, Zoltowski, Kisselburgh, & Brightman, 2019). We use this approach for two reasons. First, its ethical principles reflect a “common morality” (Beauchamp &
Childress, 2009, p. 3), and the application, or specification of those principles to specific situations, make it an appropriate lens to describe students’ ethical decision-making processes. Second, reflexive principlism emphasizes the importance of reflection, drawing our attention to when and under what conditions students reflect on their ethical decision-making so that educators can better support this process.

Reflexive principlism is “an approach to ethical decision-making that focuses on internalizing a reflective and iterative process of specification, balancing, and justification of four core ethical principles in the context of specific cases” (Beever & Brightman, 2016, p. 275). Originating from biomedical ethics, these four principles are (a) beneficence, providing benefits to society; (b) nonmaleficence, avoiding causing harm; (c) autonomy, respecting the agency of individuals in decision-making; and (d) justice, distributing risks, benefits, and costs equitably among all individuals. Principlist biomedical ethicists consider these principles to be core moral values that apply to all people, operating as “a universally-shared product with ‘authority in all communities’” (Beever & Brightman, 2016, p. 279). Although these principles prescribe guidelines for ethical reasoning, bioethicists Beauchamp and Childress (2009) explain that these principles merely “[express] the general values underlying rules in the common morality” (p. 3). Although the concept of a common morality has been debated, we follow Beauchamp and Childress’ argument that these principles reflect instinctive, normative understandings of right and wrong, such as “Don’t cause pain or suffering to others” (Beauchamp, 2003, p. 260). We, therefore, use these principles to describe and make visible the ethical decision-making of undergraduate engineers even when students cannot articulate their decisions using language such as beneficence or nonmaleficence.

Second, reflexive principlism’s ethical reasoning process reflects natural design decision-making, making it an appropriate lens to identify and describe the ethical decision-making of undergraduate engineers. As Beever and Brightman (2016) translate principlism from biomedical to engineering contexts, they argue, “the principles can be understood as constraints, and the specification, prioritization, and justification as processes similar to generation of design specifications through the building and testing of prototypes in an attempt to produce an optimized design solution” (p. 284). Drawing on bioethical principlism, Beever and Brightman (2016) argue that engineers specify larger ethical principles by placing them in specific design contexts, asking, for example, “What does autonomy look like in this particular project?” Then, as the design process moves forward, engineers encounter new information and continue to resppecify these larger principles, weighing them against one another and seeking to reach coherence among them. By using the principles and the process of specification as an analytical lens, we explicate the intuitive ethical decision-making processes of undergraduate engineers.

Beever and Brightman (2016) argue that this deliberative process requires reflection and ideally, becomes reflexive over time. They state, the “goal then, of a reflective, conscious, process is to build a skill set of ethical reasoning that is then internalized and applied in a reflexive, ‘second-nature’ way to unique situations” (p. 282). Thus, unearthing students’ intuitive ethical decision-making offers an exemplar for educators seeking to cultivate students’ ethical reflexivity, enabling instructors to help students identify the presence of principles such as autonomy and beneficence, reflect on these decisions, and discuss their alignment with prescriptive ethical principlism as described by Beever and Brightman (2016). Furthermore, we examine when and why students engage in ethical reflection in the design process. By doing so, educators can better grasp what triggers reflection, where reflective gaps may be, and how to better support students’ overall ethical reasoning skills.

2.2 | Project context

Human-Centered Design (HCD) and service-learning programs are rich sites for exploring engineering students’ ethical decision-making. In contrast to a technology-centered view of design, HCD holds “human beings as central in the process, involve[s] users throughout the design process, and seek[s] to understand them holistically” (Zoltowski, Oakes, & Cardella, 2012, p. 29). As HCD programs often require students to interact with stakeholders (e.g., users/beneficiaries, community partners, and representatives) throughout the design process, students in HCD-focused service-learning programs must navigate ethical decisions with real people in real places. Thus, service learning can facilitate an “authentic learning” experience (Hess, Strobel, & Brightman, 2017; Starratt, 2007) as students grapple with the real life complexities of ethics and design such as deadlines, limited budgets, and stakeholder relationships.

As HCD and service-learning programs are well suited to examining students’ ethical decision-making, we explicate the intuitive decision-making processes of undergraduate engineers in these contexts. Thus, we ask the following research question:

RQ1 How do the four principles of reflexive principlism appear as salient in students’ intuitive ethical decision-making throughout the course of the design process?
To examine reflection specifically, we ask the following research question:

RQ2 When and how do students engage in reflection in their ethical decision-making?

3 | METHODS

We utilized qualitative interviews to generate thick description of students’ design decisions and their retrospective sense-making of their ethical decision-making. Interviewing is an appropriate method for prompting students to reflect on their past decision-making processes (Lindlof & Taylor, 2010), enabling them to articulate the factors that played into their design choices. Furthermore, in a semi-structured interview, the interviewer asks probing follow-up questions to make participants think deeply about their answers. This reflective discussion enabled our team to draw out rich, nuanced descriptions of students’ ethical decision-making processes.

3.1 | Participants and context

Participants for this study were students enrolled in the EPICS program at Purdue University, a multidisciplinary, cross-cohort, service-learning program. In this HCD program, students develop solutions for community member or organization partners and are instructed to engage stakeholders at each stage of the design process. The primary contact for the project is referred to as the “project partner,” and the stakeholders include users who will use and/or directly interact with the product as well as those who will benefit or receive value from the project. For example, a team of students may partner with a community member with a disability to design assistive technology for them. Other teams may design products for larger social groups and partner with a specific individual or community who represents that group to determine needs and specifications (e.g., designing for those who are visually impaired by partnering with a classroom at a school for the visually impaired). We discuss findings from students on project teams in four design classes that included approximately 15 projects across three semesters. These design projects, during the time of the study, were in distinct phases of the design process, changing during the three time points of data collection.

3.2 | Procedures

We conducted semi-structured interviews with returning and new students of four design classes across three semesters, resulting in 103 total interviews. Multiple time points enabled the research team to examine how students’ descriptions of the design process, decision-making, and ethics shifted over time. Interviews focused on design decisions, team member and community partner interactions, and importantly, students’ perceptions of the ethical dimensions of their work. For example, researchers asked participants to describe the design decisions their team made at different points in the timeline. Researchers also asked such questions as “What ethical issues did your team encounter in the design process?” Each interview lasted approximately 1 hr, and once completed, all interviews were transcribed and anonymized, and pseudonyms were assigned to the participants to protect their confidentiality.

We sampled from our interview dataset to capture a range of respondents who participated for multiple semesters in the same project, seeking to understand specific participants’ ethical decision-making and the potential shifts throughout the design process. This sampling process resulted in 10 participants and 26 interviews. We then supplemented this dataset with three more participants engaged in projects at different stages of design so that collectively the dataset represented all phases of the HCD process. This sampling process resulted in a total of 30 interviews with 13 participants, including seven men and six women, all of whom identified as Caucasian. Although the sample’s gender diversity is greater than the 23% women in the College of Engineering at the time of the study, its lack of ethnic diversity does not reflect the 33% nonwhite population in the College of Engineering. The participants’ majors included mechanical engineering (4), electrical and computer engineering (4), civil engineering (1),
environmental engineering (1), aeronautical and astronautical engineering (1), and general/undeclared engineering (2). Participants were involved in 10 distinct projects in which they designed:

Project A: A calculator interface for students who are visually impaired.
Project B: An e-reader for individuals who are visually impaired.
Project C: A prosthetic device for an individual with a recently amputated leg.
Project D: An assistive device for a man with a foot disability.
Project E: Spring-propelled cars and lesson plans for middle schoolers learning physics.
Project F: Robots and lesson plans for high schoolers learning programming skills.
Project G: Lesson plans for elementary students learning about new technologies.
Project H: A lighting demonstration to teach new homeowners how to save electricity.
Project I: A community garden in the local area.
Project J: Assistive technology for a toddler with a disability.

These interviews were analyzed using a constant comparative method (Boeije, 2002) in which four members of the research team generated an initial set of codes through open coding of seven sample interviews. They then engaged in an iterative, comparative process in which team members checked their coding against one another’s, often coding interviews with one another to ensure reliability, until developing an established codebook and coding process. The research team used this codebook to analyze the remaining interviews. Codes included categories such as identification of ethics, design constraints such as feasibility or viability, and team process. We then utilized reflexive principlism to further analyze the sample of 30 interviews, identifying instances where students appeared to intuitively draw on ethical principles and where students engaged in reflection on their design decisions.

3.3 Applying the reflexive principlism framework

Scholars have debated whether bioethical principles are balanced or specified and whether certain principles have authority over others (e.g., Beauchamp, 2003; Richardson, 2000). We follow Cullity’s (2007) argument that “all questions in health care ethics are in one way or another about beneficence, its scope, limits, and proper expression” (p. 22). Thus, we argue that engineering students’ ethical questions are fundamentally about beneficence as well, particularly in service-learning and HCD programs that instruct students in providing a service to stakeholders. In these contexts, students are constantly negotiating issues of beneficence—providing a beneficial product to their stakeholders—alongside other ethical concerns. In applying this framework, we examined how students define beneficence, or what is good for their stakeholders, and further specify beneficence according to the principles of autonomy, justice, and nonmaleficence, seeking coherence among these principles and practical constraints.

To define autonomy, justice, and nonmaleficence and identify where they materialize in students’ decision-making, we draw on biomedical and engineering ethics literature. Beever and Brightman (2016) define autonomy as “supporting and respecting [others’] autonomous decisions” (p. 280) and provide an example in the engineering context as paying “attention throughout the process of design to the needs of specific stakeholders” (p. 285). Thus, we describe respect for autonomy as a salient principle in students’ ethical decision-making when they seek out and act on stakeholder feedback in design rather than simply assuming their own design ideas are best. In biomedical ethics, justice refers to “distributing benefits, risks, and costs fairly” (Beauchamp & Childress, 2009, p. 12) and is invoked in discussions of, for instance, the accessibility of certain treatments for marginalized or low-income groups. Thus, when students describe issues of fairness regarding who can gain access to their product or who is most at risk in using their product, they draw on the principle of justice in their decision-making processes. Finally, when students express concern about whether aspects of their designs could injure users, they are invoking the principle of nonmaleficence, or “avoiding the causation of harm” (Beever & Brightman, 2016, p. 280). A summary of the definitions of the four principles, as well as examples from an engineering context and representative quotations, can be found in the Appendix.

With this understanding of the principles, we examined students’ descriptions of their design decision-making to locate where the principles of autonomy, justice, and nonmaleficence emerged and shaped how students made sense of beneficence, or what is good, throughout the design process. We also identified instances of students’ reflection on their ethical decision-making to better understand what prompts ethical reflection.
4 | FINDINGS

In the following sections, we outline how student teams engaged in ethical decision-making throughout the design process, explicating how they respecified beneficence in relation to the other principles as well as engaged in reflection. To trace these processes throughout the design lifecycle, we structure the findings according to the EPICS Design Process (EPICS Design Process, n.d.), featured in Figure 1, which includes the following phases: problem identification, specification development, conceptual design, detailed design, and delivery.

4.1 | Project identification/specification development

In the first stage of the design process, project identification, students are instructed to “identify a specific, compelling need to be addressed” (EPICS Design Process, n.d.). In the second stage, specification development, they must seek to “understand ‘what’ is needed by [their] community partner, and by the end of the phase, to develop measurable criteria in which design concepts can be evaluated” (EPICS Design Process, n.d.). In the interviews, students blurred these two phases together, discussing the “compelling need” in conjunction with “‘what’ is needed.” Thus, we discuss how students engaged in ethical decision-making processes in both beginning stages of the design process.

As students engaged in the front-end decision-making for their projects, issues of autonomy and justice emerged as salient when seeking to specify beneficence, or what is good, for the project partner. These issues emerged when discussing the nature and goals of projects they could pursue in order to feasibly deliver a helpful product (beneficence) while also following the desires of their project partners (autonomy) and ensuring the device is accessible to all community members (justice).

As the students developed their understanding of stakeholder needs and project goals according to the explicit or perceived interests of their community partners, the principle of stakeholder autonomy emerged as salient for all of the teams engaged in the first two phases. However, teams designing for specific users based their understandings of “‘what’ is needed” primarily on a singular individual or group’s feedback, making the principle of user autonomy for the specific individual or group as most salient in specifying their understanding of beneficence. For instance, Projects C, D, and J attempted to improve mobility and accessibility for specific individuals with disabilities. Rather than design assistive devices according to students’ perceptions of what the users would want, students on these teams built their specifications according to their users’ ideas. Other teams designed products for specific groups, such as students in a certain class, so they developed specifications according to the teachers’ recommendations.

For example, as students on Project A began to design a calculator interface for students in a class at a local school for the blind and visually impaired, they developed their project goals according to the objectives of the classroom teacher, Miss Pebblecreek. According to Bruce, “Well, we want to make something that works for them. We’re not designing for everyone in the world; we’re designing for them right now, so we’re building everything based on what she wants and what her students want.” By stating that the team is “building everything based on what [Miss Pebblecreek] wants,” Bruce recognized the importance of Miss Pebblecreek’s autonomy in shaping what is good (beneficent) for her and her class. He acknowledged the role of the end-users—the students; however, his team relied primarily on Miss Pebblecreek’s determination of “‘what her students want.” Then he stated, “She wants a way to easily

FIGURE 1  Stages in the design process for students in the EPICS Service-Learning Program
be able to communicate with the students in two-way communication, and we can't produce two-way communication this semester, so we're going to do one-way for her for right now.” Bruce's team acknowledged that their time limitations posed constraints on Miss Pebblecreek's ideal product, but together they came to a resolution. Thus, Bruce's comment illustrates how pragmatic constraints also shaped how he and his team specified beneficence for Miss Pebblecreek as they sought to bring ethical principles into coherence with practical limitations.

Teams designing projects for a broader community rather than a specific user or small group engaged similar issues of autonomy but also grappled with issues of justice in their front-end decision-making. For instance, rather than base their project specifications on one teacher, Project H conducted door-to-door surveys with community members, gathering research on the needs of local homeowners. As a result, students learned about food insecurity in the local area, and issues of justice became more salient in their design for a community garden. Similarly, Project J sought information from a diversity of stakeholders as well as academic and market research. As Danny stated, “we had a postdoc that was blind, and we were in contact with [local school for the blind], [university office of the dean of students], and then a lot of ... research.” In this process, Danny and his teammates sought feedback from specific potential users, grappling with issues of autonomy in their decision-making. However, as they engaged more stakeholders and existing research, they also discovered the exorbitant cost of e-readers for visually impaired individuals, which made them reflect on concerns of distributive justice. As Danny described,

This particular project, it's not just about designing something and designing a pretty good prototype. It's about designing something that, whether we sell it through a nonprofit or not, we can manufacture it on a large scale and we can give it to the rest of the world. So from the very beginning, our scope was, we need to build something that we can get to everyone. So if we can build it by hand for $5,000, that's not at all good enough.

Danny's concern for the accessibility of the device to the visually impaired community demonstrates how his understanding of delivering a beneficial product to the users is shaped by justice, in effect respesifying beneficence as delivering a product that is financially accessible to a marginalized group. As he provided further elaboration, he explicitly acknowledged how doing so inevitably results in trade-offs:

So if it's bare bones and it does what we want and we take out a hundred really cool features just so we can get it to as many people as possible, and increase that ridiculous 30 percent literacy rate in the blind community, that's our goal.

In these descriptions, Danny continued to respify beneficence, describing it as delivering a “bare bones” product. As this enables the team to “get it to as many people as possible,” he illustrates how a concern for justice shaped his team's design decision-making rather than simply describing how a “bare bones” product is sufficient due to pragmatic constraints.

All teams in the first two design phases specified beneficence according to issues of stakeholder autonomy, particularly as they sought out stakeholder needs as instructed by their professors. However, for students designing for specific users, autonomy was the key principle in specifying beneficence. Teams designing for a broader community, however, relied less heavily on feedback from singular users or partners. Instead, these teams sought information from a greater diversity of sources, such as community or nonprofit members, professors, and market research (e.g., prices of comparable products). This discovery process sparked moments of reflection as students learned about more than just the partners' needs, and this process appeared to introduce more principles into teams' ethical decision-making as well. For example, Danny stated that they “need to build something that we can get to everyone,” in contrast to Bruce, who mentioned, “we're not designing for everyone in the world.” Because of this distinction, Bruce specified beneficence primarily according to his project partner's needs, whereas Danny's team engaged in more complex ethical decision-making, incorporating specific potential users' feedback (autonomy) while also making the device widely usable and financially accessible (justice). This distinction reflects Beever and Brightman's (2016) description of justice and autonomy as two ends of the “axis of stakeholder impact: individual to the collective (for one or for all)” (p. 281).

Furthermore, as students communicated upfront with stakeholders during the initial design phases, they were likely to reflect on stakeholder input on their initial design ideas. By requiring students to find and meet with partners and stakeholders in these early stages, instructors facilitated these opportunities for ethical reflection. When Bruce discussed his team's design for Miss Pebblecreek, he described how communicating with her was a way to “help keep us
in check, to make sure we’re staying on the project that she wants,” despite the ideas for a more complex design that his teammates desired. He demonstrated how, rather than merely deciding the best design among themselves, they reflected on user needs in their ethical decision-making. Teams designing for broader communities instead of singular users appeared to grapple with more principles in specifying beneficence. Like the others, these teams wrestled with issues of autonomy as they reflected on feedback from potential users and stakeholders, such as the visually impaired postdoctoral researcher. However, as they were not designing for one user, they conducted secondary research on the community and its needs as a whole. Their research on these groups also prompted ethical reflection; for instance, reading about the lack of financial resources for many in the blind community shaped the team’s decision to design a more inexpensive e-reader. As teams designing for a broader community had to seek out more kinds of information, this process introduced more ethical considerations into their decision-making process and, therefore, created a potentially more complex ethical decision-making process—where what is good is not simply what one person or group wants but what is both desirable and financially accessible to many.

4.2 | Conceptual design

In the conceptual design phase, students seek to “expand the design space to include as many solutions as possible, evaluate different approaches and select the ‘best’ one to move forward” (EPICS Design Process, n.d.). At this point, teams have begun brainstorming design ideas and seeking feedback from stakeholders. For teams working closely with project partners, the salience of autonomy intensified and reflective discussion increased, particularly when they received user and project partner feedback on design ideas. For example, Isaac on Project G, described how

through the whole lesson plan drafting experience, we were trying to talk to Bev, who was our contact down at iSPACE, and be like, “Look, does this look okay? Is this something that would be understood by fifth graders?” and then we asked the same questions when we went down to talk to the teachers, like, “Is this practical to teach in a fifth-grade classroom?”

As their team brainstormed design concepts that were accessible to fifth-graders, they leaned on the teachers’ and administrators’ feedback to choose the right design. These interactions served as important prompts for students’ reflection on issues of autonomy. The reflective discussions then shaped students’ design decisions, particularly as several teams forwent their own design ideas in order to incorporate user and project partner feedback to make a product that truly met their needs.

For example, Project B’s original design ideas were challenged by their partner’s feedback, forcing them to reconsider how they were defining what is good for their partner. This team set out to develop assistive technology for a toddler with a disability named Ryan, identifying several potential devices they thought could assist Ryan in feeding himself. However, after meeting with Ryan’s parents, Tina shared how their team’s conceptual design ideas changed:

R: I think initially, like the first week or two, we brainstormed all of these ideas, we had like a whole board with tons of different ideas, and I think once we met with the parents, that was when we finally decided on like, “Okay, we want to go with the device that you put the spoon on and spin it,” because that’s kind of what the parents were envisioning a little bit. We thought it would work really well, and it’s pretty easy for the user to use. And so that was one of the big decisions, because that kind of took our whole semester, then, to make devices that were similar to that video that the parents had showed us.
I: And that was mostly based on the parents’ preference?
R: Yeah. Um, part of it was like [pause] yeah, part of it was the parents telling us like, “He doesn’t like things to be attached to him,” which ruled out a lot of our ideas.

By admitting that the team’s design ideas did not match with “what the parents were envisioning,” the team was forced to reflect on how to provide a helpful device (beneficence) that respected the autonomy of the user and his parents. By choosing to follow the parents’ wishes, Tina and the team respecified beneficence in this particular design context,
seeking to bring it into greater coherence with the specific feedback of the user's parents even though doing so “took the whole semester.”

While in the conceptual design phase, Project D also encountered user feedback that pushed them to consider how user needs differed from their original plan. This team set out to design a brace for a man with limited mobility. Adele discussed how their first prototype, designed when brainstorming different solutions for his brace, did not meet the user's needs:

Just [pause] taking myself out of the situation and thinking about what would be best for the person we're serving. So like for our ... project, like yeah, honestly, my first thought was to go with that athletic sock, but then seeing Pat using it, well, that's clearly not working for him. We need to listen to him, listen to his needs, and stop thinking about the first thing that came to our mind and stop trying to improve that, and go with what would be best for him.

Adele's statement highlights how the user's needs (autonomy) prompted the team to reconsider how they were specifying beneficence in this context, leading them to forgo their original design. In sum, in this design phase, users' and project partners' face-to-face interaction with students' initial design concepts directly affected the teams' ethical decision-making, making many of the students reflect on their perceptions of beneficence. This process led many teams to respecify beneficence, seeking to bring it into greater coherence with autonomy of those users and project partners.

However, for teams that interacted less with users and project partners during this phase, the interviews demonstrated less evidence of reflective discussions of how stakeholder autonomy impacted the team's conceptual design. In many ways, students appeared to skip to concerns related to the detailed design stage, such as issues of safety and specific design materials. As several teams received feedback from their project partner during the first two phases, they then moved onto a detailed design stage where they sought to create a product that met those specifications. For example, the team on Project H talked with their partners at the beginning of the design process as they sought to develop a lighting demonstration for new homeowners. However, the students did not seek out much interaction during the subsequent design phases. As Jacob shared:

R: Basically, I think Paul and Preston gave out the specifications [pause] I guess it was two years ago, jeez.
I: So they gave it out like, “We want these things”?
R: “We want this, this, and this, and we want it to be able to demonstrate that stuff,” and we went from there.

As a result, students in this team engaged in less discussion about stakeholder autonomy as they appeared to follow marching orders and dive into more technical design aspects, the ethical dimensions of which are discussed further in the next section on detailed design.

However, when these teams interacted with their partners in unplanned ways, they were forced to reflect on the project partners' feedback on their design ideas. Jacob admitted that their team did not bring their original prototype to their project partners for approval as many other teams did during conceptual design, but that once the partners saw it, they provided feedback. At this point, these teams engaged in decision-making in a similar fashion as those working closely with specific partners, often respecifying what is good for the partner in light of user and project partner autonomy. For instance, Jacob mentioned:

Like, I remember there was one time we were at the pole barn, we were getting ready to put the painting demonstration unit together and we happened to run into Paul, and Paul gave us some suggestions on like how to make it smaller, a little bit more stable, and so we rolled with that. As far as the other unnamed, sorta-they're-there stakeholders [pause] well, we tried to put forward the best end product we could, but I'm not sure [pause] like, if we had more input, we probably would've used that as well, you know?

Jacob highlights the role of direct interaction with project partners in students' negotiation of stakeholder autonomy in their design decision-making. As with other teams, Jacob indicated that they modified their design after interacting with their project partner, using concerns of autonomy to respecify beneficence. However, unlike other teams that
deliberately sought out the perspectives of users and project partners, Jacob mentioned that they incorporated stakeholder feedback after they “happened to run into” their project partner. Furthermore, while Jacob hinted at the autonomy of the “unnamed, sorta-they’re-there stakeholders,” by stating that their team “would’ve used” input from stakeholders had they received it, he appears to place respecting their autonomy outside the responsibility of his design team. As these teams did not reflect on issues of autonomy unless partners approached them, they appeared to engage in less reflection during the conceptual design phase.

4.3 | Detailed design

During detailed design, students are instructed to “design a working prototype which meets functional specifications” (EPICS Design Process, n.d.). For many teams, the ethical decision-making present in conceptual design continued into detailed design, particularly as students interacting closely with users and project partners continued to grapple with issues of autonomy when developing more detailed iterations of their design. In addition to these ethical concerns, issues of nonmaleficence emerged during the decision-making of all teams in this design stage. As students ordered new or different materials or worked on the small, specific details of their prototypes, many began encountering decisions related to the technical aspects of their prototypes. During this prototyping process, teams began reflecting on and grappling with issues of safety and avoiding harm (nonmaleficence) in their design work.

For example, Bruce on Project A discussed the specific electrical components that the team had to ensure were safe to avoid shock hazards for students who are blind and visually impaired. In his interview, he discussed the ethical implications of these decisions:

I guess, um [pause] because we’re dealing with electrical circuits, you know, we don’t want to leave anything—like, we don’t want to make anything that’s like too cheap or exposed wires or something where students can actually shock themselves or something along those lines. So we want to make sure that everything’s sealed up from them.

When asked why he was concerned about these safety issues, Bruce responded, “there’s a lot of products people make really cheap, and I guess …. I think the ethical thing to do would be to take our time and to design it properly.” In this case, Bruce describes how concerns of nonmaleficence should shape how designers consider what is good (beneficent) for their users. Rather than use pragmatic constraints—such as limited time and budget—to justify unsafe design decisions, he describes the importance of spending more time on design and more money on high-quality parts so that the user receives a safe product.

Other teams discussed similar safety issues, mentioning shock hazards or possible injuries related to certain aspects of their design. When designing spring-propelled cars for elementary students, Reid discussed his team’s prototype:

I think the main reason we switched from a mousetrap to a spring was that the mousetrap was unreliable as well as very unsafe, and I think that was probably the only ethical thing we considered really, is that, you know, a fifth grader shouldn’t be messing around with a mousetrap; that’s just a bad idea.

These decisions to respecify beneficence according to nonmaleficence emerged in lab meetings, Design Reviews, or interactions with stakeholders. Teams who were not interacting with users and project partners during detailed or conceptual design often discussed issues of nonmaleficence when prototyping as they brainstormed the potential hazards of certain materials or constructions. Although peer conversations and faculty and TA interactions appeared to spark some reflection on nonmaleficence, these students did not describe much reflection at this stage. For example, Reid’s comment that the safety of the spring was “the only ethical thing we considered” during detailed design conveys limited reflection on ethical issues during this design phase. In fact, students were more likely to describe a semester spent in detailed design as a “technical semester” instead of an “ethical semester” (Brittany), demonstrating little reflection on the ethical implications of their design decisions during the prototyping process.

However, teams that interacted with project partners during detailed design were more likely to actively reflect on their decisions at this stage as many feared harming a user with a prototype. For example, Adele described how “We were just scared that we were ... going to hurt [our user].” Her team described how the end-user “tripped right away”
when trying on their prototype, causing them to immediately reflect and redesign. These interactions also created opportunities for users to provide additional feedback on what they wanted in the design, making these teams reflect again on issues of user autonomy. Thus, while most teams appeared to discuss issues of safety during this stage of the design process, teams working closely with their partners appeared to extend the considerations of user autonomy present during conceptual design into detailed design, while also incorporating more consideration of nonmaleficence at this stage. Thus, during detailed design, these teams respecified beneficence in light of both user autonomy and nonmaleficence.

4.4 | Delivery

The delivery phase proved a complex and dynamic stage for ethical decision-making as the rubber met the road for teams making final design decisions. In addition to managing the pressures of producing a final prototype, teams that delivered their product attempted to do so at the end of the semester, a busy season for the undergraduate students. As a result, students grappled with time constraints, stakeholder needs, class expectations, and team dynamics. Thus, the students negotiated the messy interconnections between beneficence, justice, and autonomy during delivery; however, for many groups, this stage posed a significant temptation to avoid actively negotiating ethical issues. In fact, it was often during the end-of-semester reflective activities that students engaged in the most discussion of their team’s ethical decision-making.

At this stage, all teams had to confront stakeholder feedback on final prototypes, forcing those teams distanced from their project partners to reflect on issues of user autonomy, often causing them to question whether their prototype met their project partners’ expectations. For instance, some teams working with specific users often emerged from detailed design phases intending to deliver a product to their partner only to discover their partner did not like it. In her interview about her current project, Project C, Adele reflected on what she learned in a past experience designing for an older woman with a disability. She described delivering their prototype to the user:

Most of us were on [Team 3] and so from that side of things, we saw that what was delivered to Patty wasn’t what she wanted, but then when we changed it and gave it to her, that was what she wanted.

In this example, Adele’s team had to respecify beneficence when confronted with issues of user autonomy. By changing their design and redelivering the product, they achieved greater coherence between autonomy, beneficence, and practical constraints. In this exchange, she also revealed how prior experience shaped her current approach to ethical decision-making.

Jacob, on Project H, expressed a similar sentiment:

I would say the only issue is, towards the end of the semester, trying to get a product to [the nonprofit organization] at the expense of making it like as much of what [the organization] wanted as possible. Granted, nobody’s really going to be hurt by that, but, you know, I guess [pause] when we took on this project, we wanted to make it like the best thing possible for [the organization], and if we’re rushing it at the end, that’s kind of...

In this statement—and by trailing off at the end—Jacob conveys the difficulty of delivering a product to the project partner within time constraints while respecting and incorporating the partners’ interests (autonomy). He appears to re-specify beneficence as delivering a product at all by the end of the semester rather than fitting it to the users’ specifications (autonomy). Unlike the other teams that also described this tension, Jacob appeals to nonmaleficence to justify his team’s decision, arguing that no one would be “hurt” by their decision to deliver a product that did not meet the user specifications.

Furthermore, Jacob stated that, in the beginning of the design process, his team wanted to make the “best thing possible for [the organization],” but toward the end, they felt the pressures of the deadline and the temptation to deliver a product less aligned with the partner’s interest. This statement reflects differences in some teams’ sense-making between the beginning and the end of the design process. In the early phases of design, most students were concerned with providing benefits to their users in ways that align with the partner’s desires and, therefore, specified beneficence according to autonomy. Although the team continued to try to deliver a beneficial product at the end, the stress of the delivery phase posed temptations for teams to cut corners in meeting the user’s specifications. Thus, this finding
suggests that practical concerns at the end of the design process may shape students’ decision-making more than the ethical ideals discussed at the beginning. As the research interviews took place at the end of the semester, this process sparked reflection for many students, especially those who had recently delivered their product to their partner. For example, the interview prompted reflection from Jacob, as his statement above conveys how his team’s ethical decision-making shifted throughout the design process.

During the delivery phase, issues of justice became more salient to many students as well, often interacting with beneficence and autonomy in more visible ways. Jacob reflected on delivering an online game to their project partner the previous semester, conveying his doubts about whether it was what the community wanted and whether it was a product that was accessible to the community:

But is that really what [the organization] wanted, you know? Like [pause] like what [pause] (sigh)? Like, are all the new homeowners going to be able to take that back with them? Like, I don’t know how many of them have computers at their house, you know, stuff like that.

Jacob’s verbal and nonverbal communication conveys his questioning of whether their final product truly met the needs of the community. While they were able to deliver a product to the project partner, he wondered if that was “what [the organization] wanted.” Through his pausing and sighing, he expresses a sense of dissatisfaction with a product not aligned with the project partner’s interests, wondering whether their device was actually accessible to the community. By doing so, he debates whether they achieved coherence among the ethical principles such as justice and autonomy concerns as well as their practical constraints.

Students working on Project E reflected on whether their product was accessible to those who have disabilities—a consideration that did not emerge in the design process until Design Review after the product had been delivered. When describing the spring-loaded cars designed by his team, Reid admitted, “You really had to kneel down and sit there and wind it up. I don’t think a kid in a wheelchair could have done the activity.” He then stated:

I think if the project partner had said that, like, “Hey, you know, you need to make sure the student in a wheelchair could use it,” I think we would’ve, but I didn’t really think that there was much of a need for it, being that only one of the students could use the car, anyway, out of the four in each group.

Reid suggests the presence of project partner input (autonomy) would have likely forced them to reflect and respecify beneficence, leading them change their design. As the project partner had not said anything, a justice-oriented concern was overlooked in favor of delivering the product to the user. Thus, at the end of the semester, students appeared to grapple more openly with issues of autonomy and justice when respecifying beneficence.

For teams who did not interact closely with their partners after the initial design phases, most reflective questioning of their ethical decision-making appeared to emerge during the delivery phase as students received feedback from project partners, professors, and others during their end-of-semester design review and through the documentation processes. For Reid’s team, the realization that their product may not be accessible to students with disabilities began during Design Review, and then while his team was documenting their design and reflecting on their decision-making:

We realized it during the documentation, actually. Because I think that they were talking about a similar thing, like ethics, and I know [the TA] went off on something about that for a while, talking about how you need to consider everyone.

Reid’s comment about how the TA “went off” about ethics also signals the significance of the Design Review process, during which the TA voiced these concerns. Then, through the documentation process, the team reflected on this feedback. Thus, the delivery phase appeared to force more reflection from the teams, whether they were interacting with the feedback from the user, the feedback from their Design Review, or the documentation process in which they formally articulated their design decision-making. In this stage, students engaged in decision-making with more principles readily visible, such as issues of autonomy and justice. In short, even though teams working closely with users interacted with their desires and feedback more readily throughout the semester, the delivery phase served as a form of reckoning in ethical decision-making for teams that operated at a greater distance from users and project partners.

As a result, the delivery phase highlighted how some teams operating at a greater distance from their users engaged in potentially unethical decision-making in the design process. Although students did not explicitly identify decisions as
| Design phase                              | Project teams\(^a\) | Ethical principles salient in decision-making | Primary reflection triggers\(^b\) | Emergence of reflection triggers |
|------------------------------------------|----------------------|-----------------------------------------------|-----------------------------------|-----------------------------------|
| Project identification and specification development | Those designing for singular user/group (A, C, D, J) | Autonomy | Heavy interactions with partners/users; interactions with professors | Interactions with the project partner were frequent triggers for ethical reflection as these teams met with the partners early in the design process to gather information about their needs and specifications. Students were encouraged to do so by their HCD instructors, demonstrating the interplay between HCD, instructor advice, and user interaction for ethical reflection. |
|                                           | Those designing for broader community (B, G, H, I) | Justice, autonomy | Interactions with partners/users, professors, and stakeholders; research literature | These teams interacted less heavily with users/partners and combined these data with that from other stakeholders (e.g., community or nonprofit members), experts (e.g., professors), and research (e.g., prices of comparable products). Doing so sparked moments of reflection as students learned about more than just the partner’s needs. For example, through interviews with community members, students learned about food insecurity, and issues of justice became more salient in designing a community garden. |
| Conceptual design                         | Those in contact with partners (A, B, C, D, G, J) | Autonomy | Interactions with partners/users | For teams working closely with users/partners, user/partner feedback on initial design concepts sparked increased considerations of autonomy. Students’ reflection on issues of autonomy prompted several teams to redesign according to user/partner input. |
|                                          | Those with minimal/no contact with partners (E, F, H, I) | Nonmaleficence | Prototyping\(^c\); interactions with professors | Little evidence of ethical reflection emerged in teams with minimal contact with partners. Students appeared to skip ahead to detailed design and began prototyping, a process that occasionally sparked considerations of risk and safety (nonmaleficence). Conversations with faculty or TAs in the lab also appeared to stimulate conversations about nonmaleficence. |
| Detailed design                           | Those in contact with end-users (A, B, C, D, G, J) | Nonmaleficence autonomy | Interactions with end-users; prototyping | Interactions with partners spurred considerations of autonomy alongside nonmaleficence, particularly as students discussed the safety implication of their prototypes for users or as the partners themselves tried the prototype and raised issues related to preference (autonomy) and safety (nonmaleficence). |
|                                          | Those with minimal/no contact with users (E, F, H, I) | Nonmaleficence | Prototyping\(^c\); interactions with professors | Little evidence of ethical reflection emerged in teams with minimal contact with project partners. The prototyping process occasionally sparked considerations of risk and safety (nonmaleficence). Conversations with faculty or TAs in the lab also appeared to stimulate conversations about nonmaleficence. |

\(^a\) Project teams are labeled with letters from A to J.

\(^b\) Primary reflection triggers include interactions with partners/users, professors, and stakeholders; research literature.

\(^c\) Prototyping in the context of ethical reflection.
unethical, many wondered aloud in the interviews as to whether their design choices were the best for their project partner. Several questioned whether they had appropriately taken issues of autonomy (user desires) or justice (e.g., user accessibility) into account, or in other words, had achieved a proper coherence among principles and practical constraints. In addition to concerns over appropriately negotiating principles, students often hinted that they did not consider principles at all, especially in light of their course loads and semester time limitations, causing them to question whether they had made ethical decisions. As students appeared regretful or dissatisfied with these choices, these findings suggest that students perceived these decisions as possibly unethical and wished they had acted differently. Furthermore, many of these hesitations and insights emerged during the interview process at the end of the semester, suggesting that careful questioning about ethics triggered students’ reflections on their ethical—or unethical—decision-making throughout the design process.

### 4.5 Summary of findings

This study has examined how ethical principles emerge as salient in the various stages of the design process as well as what activities prompt students’ reflection on their ethical decision-making (see Table 1). Thus, this project identified how aspects of certain design phases (i.e., prototyping during detailed design) are likely to spur considerations of certain principles (i.e., nonmaleficence). However, across design phases, the teams’ interactions with users and project partners proved the most dominant factor in shaping students’ ethical decision-making and in triggering reflection. For example, all the teams in the beginning phases grappled with autonomy as they sought stakeholder needs and feedback on specifications. However, as the design process progressed, students who stayed in contact with their project partners continued to respecify beneficence according to issues of autonomy, particularly for the partners with whom they were in most contact. Despite discussing issues of nonmaleficence during detailed design, teams who did not seek feedback from stakeholders after the first phases often did not reengage with issues of autonomy and other principles until the end of the design process as they interacted with users and project partners during delivery and professors and stakeholders during Design Review, documented their design processes, and reflected on their ethical decision-making during interviews.

As a result, teams working closely with users and project partners throughout the process appeared to engage in more active, reflective discussion about their ethical decision-making, whereas teams removed from project partners were more likely to reflect on their decision-making at the end of the design process or later in the interviews themselves. These teams were also more likely to question their ethical decisions, often wondering whether they provided a beneficial product to their users.

| Design phase     | Project teams | Ethical principles salient in decision-making | Primary reflection triggers | Emergence of reflection triggers |
|------------------|---------------|---------------------------------------------|----------------------------|----------------------------------|
| Delivery         | All teams that delivered (C, D, E, F, G, I, J) | Autonomy, nonmaleficence, justice | Interactions with users/partners, documentation, design reviews | The delivery process fostered ethical reflection from all teams as students received feedback from their users/project partners and from professors and community members during design reviews, and responded to reflective questions during the design documentation process. Teams with less contact with users and project partners throughout the design process appeared to question the ethicality of their design decisions during delivery and post-delivery stages. |
| Outside design process | All teams (A-J) | Autonomy, nonmaleficence, justice | Interviews for study | Interviews sparked retrospective sense-making of students’ decisions, drawing out hesitation from students who interacted less closely with project partners. |

*During the 1.5-year data collection process, not every team experienced every stage of the design process. Thus, not all 10 teams are represented in each design phase.

*These are the primary reflection triggers that emerged during these phases, not all of the triggers.

*The prototyping process appeared to spark some conversations about nonmaleficence, yet students in these teams did not report much ethical reflection during these stages.
5 | DISCUSSION

5.1 | Implications for ethical sensitivity and reflectivity

As research on ethical sensitivity and reflectivity indicate, reflecting on one’s intuitive ethical decision-making, particularly alongside ethical frameworks, can build ethical reasoning skills. As these findings portray how students intuitively engage in ethical decision-making, they have implications for how educators can develop students’ ethical sensitivity and reasoning skills. Furthermore, by describing students’ ethical decision-making in the context of reflexive principlism, educators can observe students’ decision-making processes within the context of an ethical framework useful for training students’ ethical reasoning.

5.1.1 | Ethical sensitivity

As students working closely with project partners and users demonstrated sustained attention to issues of autonomy, they expressed greater sensitivity toward users’ needs. This finding supports earlier studies on HCD, in which increased user engagement resulted in more “comprehensive” understanding of design among students (Zoltowski et al., 2012, p. 48) as they are “confronted with the need to take more factors/aspects into consideration into the design” (p. 48). Similarly, as these students actively reflected on project partner and user needs, they were more likely to demonstrate forms of perspective taking. Perspective taking involves considering “the needs and values of numerous stakeholders with whom [engineers] may never directly interact, but who will be affected by the use and impact, including the unintended use and consequences, of their solutions” (Hess et al., 2017, p. 535). In this way, students working closely with project partners and users throughout the design process demonstrated more ethical sensitivity. However, certain design phases that required interactions between students and users appeared to facilitate ethical sensitivity as well. For example, students demonstrated much ethical sensitivity during the last phase as they delivered their product to their project partners and users, even questioning if their decisions were ethical. Educators could leverage how the delivery process prompts sensitivity toward user needs, potentially asking students earlier in the design process to consider how they would feel delivering a subpar product to the user.

Students distanced from project partners and users demonstrated awareness of their needs and concerns as well, but they did not incorporate them into their design decisions as intentionally or consistently. These students conveyed hesitancy about whether they had adequately met user needs, suggesting that their ethical sensitivity did not always influence their ethical decision-making. This finding reflects prior research indicating that mere confrontation with a user’s feedback does not necessitate a response that attends to their needs. Sugar (2001) describes how some students reverted to simplistic solutions that did not critically engage user feedback, for example, eliminating the element of their design discussed by users or resorting to a “band-aid” solution that superficially addresses their concerns. Some evidence of these approaches emerged among teams that interacted infrequently with their project partners and users. Thus, these findings suggest that ethical sensitivity plays a more active role in students’ ethical decision-making when students maintain relationships with their project partners and users throughout the design process. It appears that students cannot as easily apply simplistic solutions when they sustain long-term contact with users and partners and continually face their feedback. This finding demonstrates the value of analyzing students’ decision-making throughout the design lifespan and the differences between teams that sustained relationships with their users and partners throughout the design process and those that did not.

5.1.2 | Ethical reflectivity

Furthermore, the findings suggest that the incorporation of user feedback into design is a product of students’ reflective discussion. All students demonstrated some ethical sensitivity, yet active discussion and reflection pushed some teams beyond ethical sensitivity into engaging issues of autonomy and implementing user feedback in their designs. As these students were less likely to question the ethicality of their decisions, this finding reinforces the importance of reflection in developing students’ ethical reasoning (e.g., Turns et al., 2014; Walther et al., 2011). This theme also highlights the unique role of user interaction in stimulating students’ ethical reflection. Whereas past scholarship in engineering education identifies how peer and faculty relationships can prompt ethical reflection (e.g., Walther et al., 2011), this study suggests that relationships with project partners and users have a unique capacity to do so.
As the findings suggest that sustained interaction with project partners and users cultivates ethical sensitivity and reflectivity, they highlight the possibilities of “authentic engineering experiences” for hands-on ethics training (Hess et al., 2017, p. 574). Since repeated acts of reflection build engineers’ ethical reasoning skills (Beever & Brightman, 2016), requiring students to interact with users and other stakeholders creates ample opportunity for students to engage in ethical decision-making. Therefore, this study highlights the practical value of service-learning engineering programs in which students encounter authentic design situations involving real people in real places rather than theoretical scenarios in engineering classrooms. However, educators can explore how to replicate this reflective process in educational environments when user interaction is not always readily available. For example, in this study, stakeholder research, design reviews, documentation processes, and even interviews themselves stimulated students’ ethical reflectivity. Thus, educators who facilitate students’ interactions with stakeholders and provide these opportunities for students to reflect on their ethical decision-making can leverage multiple forms of reflection triggers.

Despite the benefits of students’ interactions with stakeholders and users, the study also suggests that a strong emphasis on users may lead to students over-associating ethical concerns with user concerns. Although this study examined interviews for evidence of ethical consideration that extended beyond user concerns, students primarily associated ethics with user impacts. For example, even students who sought out multiple stakeholders and considered multiple ethical principles appeared to equate ethics with user concerns rather than, for instance, secondary stakeholders or environmental impacts. In some cases, students appeared to extend the comparison of user concerns with ethical concerns even further, equating user feedback with ethics, such as Reid stating how his team would have considered users with disabilities had their project partner mentioned it. In this case, the overemphasis on user input suggests students may even outsource their ethical decision-making to users and project partners, and as a result, not consider the breadth of potential ethical implications for their design decisions. These themes reflect findings in studies of HCD in which students hyper-associate ethical decision-making with user interaction (Kenny Feister, Zolowski, Buzzanell, & Torres, 2016), foreclosing the possibilities for more complex understandings of ethical reasoning.

### 5.2 Implications for educators using reflexive principlism

We encourage the adoption of reflexive principlism as a way of developing students’ skills in navigating the complexities of everyday ethical decision-making. As Beever and Brightman (2016) argue, “a common or consistent approach to specifically developing ethical reasoning has not been adopted” (p. 277), and existing approaches typically employ narrow codes of ethics or case analyses of disaster scenarios rather than real-life situations. As demonstrated by our analysis, we agree that reflexive principlism provides a helpful “level of generalization about moral and ethical considerations that is most appropriate for engineers in training to handle when confronted with novel and emerging ethical issues” (p. 286). Thus, this study offers insight into how educators might use reflexive principlism in descriptive ways to identify and display students’ intuitive ethical decision-making in design contexts, better enabling educators to help students apply the ethical framework in prescriptive ways. For example, educators can ask students in design courses to write down how they navigated ethically challenging design decisions, what their decision-making processes were and why. Then, educators can use Beever and Brightman’s text to teach students the four principles of reflexive principlism and describe how they may materialize in engineering contexts. Afterwards, educators can ask students to examine their written decision-making processes to identify if and where the moral principles appear in their thinking. In this way, after using reflexive principlism descriptively, educators can use reflexive principlism as a prescriptive approach for ethical reasoning in design. For example, using reflexive principlism prescriptively would encourage exploration of how all of the principles impact design decisions and, subsequently, all of the stakeholders, and expand the scope of the principles considered during ethical decision-making. In the study, as students designing for a singular user or group grappled primarily with issues of autonomy, there may be benefit in pushing students to consider the ethical complexities of designing for many instead of one.

We also encourage educators to be more explicit in describing how the moral principles materialize in the design process. As students are likely familiar with the concept of design constraints, we suggest framing the processes of specification and balance within constraint language, thereby drawing more visible linkages between abstract moral principles and concrete engineering design decisions. Doing so would extend reflexive principlism’s utility more tangibly into engineering contexts and enable students to consider how constraints are not necessarily amoral technical decisions, but carry larger ethical implications.
6 | SUMMARY OF IMPLICATIONS FOR ENGINEERING EDUCATORS

By recognizing how students’ ethical decision-making and reflection emerge throughout the design process, educators can better structure and support these processes. More specifically, this study highlights the possibilities and constraints of user and project partner interaction sparking ethical reflection among students and demonstrates the utility of crafting more authentic learning experiences for students. Similarly, as activities such as design review and documentation facilitated students’ reflective conversations, educators can combine these strategies with user interaction to maximize students’ reflection. For instance, educators may consider scheduling stakeholder and user check-ins for students throughout the design process, and assign students small reflective activities to process and document these meetings and subsequent design decisions. Doing so would combine suggestions from research on reflection activities for ethics education (e.g., Walther et al., 2011) with in-situ conversations with users. Educators can also incorporate user and multistakeholder reviews of students’ designs and require documentation throughout design phases rather than at solely at the end. We also suggest educators use reflexive principlism as a framework in this process, giving students language to use as they reflect. Doing so would help students make their intuitive decisions more explicit and enable them to reflect on their ethical decision-making alongside of the prescriptions of reflexive principlism.

6.1 | Limitations and future directions

Although reflexive principlism is a useful tool in explicating ethical decision-making, applying it to students’ retrospective accounts has its limitations. Prescriptive frameworks for ethical reasoning present an ideal for decision-making. As ethical decision-making does not operate in an ideal space, students' selfish—arguably unethical—decisions are not wholly captured by reflexive principlism. Instead of indicating unethical behavior, the framework enabled us to interpret students’ questioning of their ethical decision-making in light of failing to appropriately specify principles or engage in a reflective process at all. As educators instruct students in ethical reasoning, they should equip students to evaluate what constitutes an unethical decision and how to identify it. We suggest that more thoroughly discussing the unethical would further extend the utility of reflexive principlism for engineering educators.

Additionally, this study lacks the perspectives of students of color. As these students may engage in ethical decision-making in different ways, future research should seek out how cultural differences shape in-situ ethical decision-making. We also recognize that this study takes place within an HCD-focused program where students are sensitized to stakeholder needs and, therefore, may overemphasize ethical concerns of autonomy. Furthermore, due to students’ association of ethical concerns with project partner concerns, future work should explore students’ ethical decision-making in different course contexts as well. Finally, future research could incorporate observations of students’ interactions to better understand how ethical decision-making unfolds in context.

6.2 | Conclusion

In sum, this project examines the ethical decision-making and reflection of undergraduate students as they grapple with messy, real-life design situations. Although certain aspects of the design process appeared to prompt consideration of specific ethical principles, students’ interactions with users and stakeholders stimulated the most reflection on their ethical decision-making. Sustained interaction with users and project partners yielded greater gains in students’ ethical sensitivity and reflectivity. If educators facilitate students’ interactions with stakeholders alongside of activities that stimulate ethical reflection, such as documentation strategies or reflective journals, educators can better structure and support students’ ethical reasoning.

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### APPENDIX A: OPERATIONALIZATION OF THE REFLEXIVE PRINCIPLISM FRAMEWORK

| Ethical principle | Definition | Example in engineering context | Representative quotation |
|------------------|------------|---------------------------------|--------------------------|
| Autonomy         | “Supporting and respecting [others’] autonomous decisions” (Beever & Brightman, 2016, p. 280) | Paying “attention throughout the process of design to the needs of specific stakeholders” (p. 285). | “And [the teammates] were going through and having, like, wires you could bend and put up there and make all this stuff. And if that was what [the project partner] wanted, it’d be great, but at least in my opinion, I feel like she wasn’t going there. So I think for the most part we use [interaction with her] to help keep us in check, to make sure we’re staying on the project that she wants.” —Bruce (Project A) |
|                  |            |                                 |                          |
| Justice          | “Fairly distributing benefits, risks, and costs” (Beever & Brightman, 2016, p. 280) | Making products/designs that are accessible to marginalized communities and respect their dignity | “Understanding that the [Nonprofit’s] homeowners are lower income, but that doesn’t depict anything about who they are. So like designing a home that like you would still want to stay in, too, or anybody would want to stay in, and not just going for like a cheap option or anything.” —Ginny (Project H) |
|                  |            |                                 |                          |
| Nonmaleficence   | “Avoiding the causation of harm” (Beever & Brightman, 2016, p. 280) | Avoiding designs with components that could harm end-users | “We were just scared that we were either going to hurt him more, because, um [pause] it was actually my biggest fear.... And then it was just in that short period of time, he had gotten so used to the brace helping him that he tripped right away. And so then I was just like, oh, we are going to hurt him.” —Adele (Project D) |