

Investigating the Contextual and Shifting Nature of Ethics within Engineering Design Teams across Time

David Torres, Purdue University

David is a third year doctoral candidate in the Brian Lamb School of Communication at Purdue University pursuing a PhD in Organizational Communication with a minor in data analysis and research methodology. His research interests reside at the intersection of organizational communication, identity, design, and organizational ethics.

Dr. Carla B. Zoltowski, Purdue University, West Lafayette (College of Engineering)

Carla B. Zoltowski is an assistant professor of engineering practice in the Schools of Electrical and Computer Engineering and (by courtesy) Engineering Education at Purdue University. She holds a B.S.E.E., M.S.E.E., and Ph.D. in Engineering Education, all from Purdue. Prior to this she was Co-Director of the EPICS Program at Purdue where she was responsible for developing curriculum and assessment tools and overseeing the research efforts within EPICS. Her academic and research interests include the professional formation of engineers, diversity and inclusion in engineering, human-centered design, engineering ethics, leadership, service-learning, and accessibility and assistive-technology.

Dr. Megan Kenny Feister, California State University, Channel Islands

Megan Kenny Feister is an Assistant Professor of Organizational Communication at California State University Channel Islands. She is a recipient of the Purdue Research Foundation dissertation grant and co-wrote a National Science Foundation grant for her dissertation and postdoctoral work in Organizational Communication at Purdue. Her primary research interests include collaboration and innovation; negotiations of expertise in team-based organizational work; team processes and decision-making; ethical reasoning, constitution, and processes; engineering design; technology and its impacts on organizational and personal life; network analysis; as well as organizational identity, identification, and culture.

Prof. Patrice Marie Buzzanell, Purdue University, West Lafayette (College of Engineering)

Patrice M. Buzzanell is a Distinguished Professor in the Brian Lamb School of Communication and the School of Engineering Education (courtesy) at Purdue University. She also serves as the Butler Chair and Director of the Susan Bulkily Butler Center for Leadership Excellence. Editor of four books and author of over 175 articles and chapters as well as proceedings and encyclopedia entries, her research centers on the intersections of career, change, leadership, and resilience. Fellow and past president of the International Communication Association, she has received numerous awards for her research, teaching/mentoring, and engagement. She has worked on Purdue-ADVANCE initiatives for institutional transformation, the Transforming Lives Building Global Communities (TLBGC) team in Ghana through EPICS, and individual engineering ethical development and team ethical climate scales as well as everyday negotiations of ethics in design through NSF funding as Co-PI. [Email: buzzanel@purdue.edu]

Danielle Corple, Purdue University

Katharine E. Miller, Purdue University

Investigating the shifting nature of ethical reasoning in the context of human-centered design across time

Introduction

Engineering design is a social practice in which ethical issues arise throughout the design process and in the everyday decision-making and communication within a design team. Emerging team member relationships and experiences play a significant role in shaping how individuals conceptualize ethics and everyday ethical issues that arise. Contextual influences are especially important for how individuals conceptualize ethics and design¹. For instance, does the context of a particular design phase and proximity to the user (i.e., Needs Assessment vs. Detailed Design) shape individuals' understanding of ethics in design? In this paper, we build upon findings in Feister, Zoltowski, Buzzanell, and Torres² and extend the examination of student ethical reasoning into a longitudinal format. As part of a larger project, the current study examines; a) how descriptions of ethics emerge and develop within design teams; b) how descriptions of human-centered design (HCD) change over time; and c) how ethical reasoning and understandings of human-centered design, accounting for contextual influences, co-occur and evolve over time. Ultimately, the aim of this study is *learning* about these deeply embedded social processes rather than *proving* the impact of each³. Our study is guided by the following research question:

RQ: *How are student designer's ethical orientations shaped by and/or shape understandings of human-centered design over time?*

This research question is particularly relevant for engineering educators given the possible implications for developing more comprehensive understandings of HCD, as well as, more sophisticated approaches to ethical development. This study also takes into account the context dependent nature of both ethics and design and thus presents implications for learning and teaching within the context of student design. Unfortunately, to date, there are relatively few studies that examine ethical orientations in engineering *and* understandings of HCD as mutually interdependent social phenomena. Thus, this study serves as a preliminary phase in developing theoretical descriptions of the emergent nature of ethical reasoning and HCD understanding over time.

Given the lack of theoretical attention to these embedded and reflexive social processes, we institute a preliminary case study^{3,4,5,6,7} framework focusing on longitudinal, qualitative interview data from two distinct team members of a student design team at a large public Midwestern university. These cases were selected as a subset of a larger qualitative data pool to develop an initial understanding of the emergent nature of ethics and design. Case study research typically involves a deep inductive exploration of an emergent phenomenon and the underlying logics that connect relationships among and between related constructs⁵. Case and Light³ state case study research also reveals the context dependent nature of knowledge. For the current study, we are interested in the contextual influences of ethical reasoning and HCD understanding. Eisenhardt and Graebner⁵ liken case studies to laboratory experiments typically found in more traditional "theory-testing" research:

...each case serves as a distinct experiment that stands on its own as an analytic unit. Like a series of related laboratory experiments, multiple cases are discrete experiments that serve as replications, contrasts, and extensions to the emerging theory (Yin, 1994). But while laboratory experiments isolate the phenomena from their context, case studies emphasize the rich, real-world context in which phenomena occur (p. 25).

Case study research thus examines a particular analytic unit within context and provides a practical, “real-world” description of the phenomenon. In this study, we focused on interview data from two individual team members of a student-led design team across two distinct time points. Therefore, the cases used for this study included each time point per team member – or a total of four distinct cases. These qualitative accounts not only provided a more nuanced view of conceptualizations over time but also identified contextual and situational influences (e.g., different phases in the design process) that may have played a role in these changes. Our semi-structured interviews focused on definitions and descriptions of ethics, as well as how participants made sense of the design processes their team followed, including asking them to describe the choices the team made along a timeline. The in-depth interrogation of these qualitative data provides insights that can then produce new knowledge and understandings about how ethical reasoning operates in situ.

In this paper, we unpack the ethical reasoning mechanisms student designers maintain as they interpret and experience human-centered design. We combine Perry’s^{8,9} ethical development schema to understand the ways students’ ethical development evolves, with Zoltowski, Oakes, and Cardella’s¹⁰ phenomenographic study of students’ understandings of human-centered design. Together, these models provide a framework for understanding how students’ ethical orientations shape, and are shaped by, how they understand human-centered design over time. This approach also highlights how contextual influences, such as specific design phases, may shape students’ orientations and understandings.

Background Literature

In the following sections we describe Zoltowski et al.’s¹⁰ HCD framework and Perry’s Cognitive and Ethical Development Model in more detail.

Human-Centered Design (HCD)

Zoltowski, Oakes, and Cardella’s¹⁰ phenomenographic study of human-centered design (HCD) provides a framework to explore changes in students’ understanding of HCD over time. Phenomenography has its roots in educational research in Sweden, arising from recognition that the qualitatively different ways in which learners experienced or understood a phenomenon were related to the qualitative differences in the outcome of that learning^{11,12}. Phenomenography has been used in engineering education to explore sustainable design¹³, design students’ experience of engagement and creativity¹⁴, and the ways that design has been experienced by professionals in a variety of disciplines¹⁵.

The outcomes of phenomenographic study are the categories of description and outcome space. Marton and Booth¹⁶ state that within that outcome space, “the qualitatively different ways of experiencing a particular phenomenon, as a rule, form a hierarchy” (p. 125). This is based on the expectation that since the categories of description represent the relationship between the phenomenon and the person experiencing the phenomenon, the categories themselves should be logically connected through the experienced phenomenon¹⁷. While a way of experiencing might be unique to the individual and the setting in which they experienced the phenomenon, a category of description refers to a coherent grouping of similar ways of experiencing the phenomenon among (typically) more than one individual.

For Zoltowski et al.’s study, analysis of the data yielded seven qualitatively different ways in which the students experienced human-centered design (categories) within the context of “designing for others”. An overview of the categories of description is given in Table 1.

Table 1. Categories of Description of Students' Experience of Human-Centered Design¹⁰

Category of Description (Human-Centered Design is...)	Summary
Category 1: Technology-Centered	Design is not human-centered, but technology-centered design. The focus of the design is on the technology and solving the technical problem, not on the “others” or humans. The approach lacks both an understanding of the users and an appreciation for the users’ knowledge, experience, and perspective.
Category 2: Service	Human-centered design is not design but service, helping or positively benefitting others but utilizing very limited, if any, design methods or processes to achieve that goal (e.g., needs assessment, iteration, decision-making tools, convergent and divergent thinking, balancing of constraints, perspective-taking, getting feedback, or prototyping).
Category 3: User as Information Source Input to Linear Process	Human-centered design is a linear design process where users and other stakeholders are viewed primarily as sources of information, assistance, and/or support, not those whose needs should be reflected in design.
Category 4: Keeping the Users’ Needs in Mind	Human-centered design is keeping the users’ needs and how design will be used in mind while designing. This approach involves gathering information about the users primarily from higher level stakeholders or experts versus the users directly. Integrating that information with aspects of technical feasibility and viability is done to the extent that disciplinary knowledge allows.
Category 5: Understanding the Design in Context	Human-centered design is understanding the design in context, seeking knowledge not only about the stakeholders’ needs and how the design is used, but also more broadly about the social, political and/or environmental context.
Category 6: Commitment to Involving Stakeholders to Understand Perspectives	Human-centered design is a commitment to involving stakeholders in the design process to understand their perspectives, seeking and taking into consideration contextual information and balancing multiple perspectives.
Category 7: Empathic Design	Human-centered design is Empathic Design, basing design on knowledge gained through a connection with end users, not on preconceived ideas and assumptions. A very broad understanding of stakeholders is developed beyond scope of project by interacting with users informally and in social situations.

The seven categories of description resulting from the study formed an outcome space that was two-dimensional with distinct, but not independent, axes: “Understanding of the Users” and “Design Process and Integration”. The axes depict complex constructs and have scales that were derived from the categories themselves and are ordinal in nature. Five of the categories were nested hierarchically. From less comprehensive to more comprehensive, those categories included: Human-centered design as “User as Information Source Input to Linear Process”, “Keep Users’ Needs in Mind”, “Design in Context”, “Commitment” and “Empathic Design”. Two categories represented ways of experiencing human-centered design that were distinct: design was not human-centered, but “Technology-Centered” and human-centered design was not design, but “Service”.

Perry’s Cognitive and Ethical Development Model

Perry’s^{8,9} schema describes the development of how undergraduate students experience and interpret their many lived experiences. Perry’s framework charts both the intellectual and ethical development of students, however, in the current study we focus on his theory of ethical development. Similar to Clarkeburn and colleagues¹⁸, we focus on changes of “basic conceptions of morality; what are the sources of moral answers, whether there are absolute moral answers, and how one is to commit oneself to different moral values” (p. 443). Perry’s original schema consisted of 9 individual positions students experienced in their intellectual and ethical development. Similar to studies using Perry’s schema^{19,20,21,22,23} we follow a condensed version representing three broader “meta-ethical development” categories¹⁸. These categories include dualism, multiplism, and commitment. As a framework for ethical development, each category indicates an increase in ethical maturity with each position building on the previous. The end goal in this scheme is “relativism”²³ or an authentic realization that moral answers are relative and contextual.

This model is situated in the undergraduate context given Perry’s extensive qualitative study examining the intellectual and ethical development of students over the span of their undergraduate careers. The schema begins with a dualistic orientation where students’ perceptions of the world are described in strictly absolute terms (i.e., right or wrong, ethical or non-ethical, technical or non-technical). Following a meta-ethical framework, students’ conceptions of morality come in right or wrong terms. The sources of moral answers reside primarily with authority figures (e.g. teachers, law, school) and there are absolute moral answers regardless of situation. According to the Perry schema, as student progress in their ethical development they begin to recognize the multiplistic nature of their lived experiences. In other words, students develop an understanding that life does not occur in strict dualistic terms. Students begin to realize that moral answers are contextual and relative to particular situations. As students develop more of a multiplistic ethical orientation, they come to realize the possibilities of many moral answers; that these moral answers are contextual and not absolute across all settings; and that traditional authority figures are not always the source of all moral answers. The final transition in Perry’s schema involves students’ recognition of “legitimate relativism” and a commitment to choose among a set of values within a pluralistic world. Students in this final and more advanced ethical orientation again recognize and acknowledge the legitimacy of moral relativism and as such commit to a particular set of moral values. Katung and colleagues²³ summarize the trajectory of students’ ethical development:

the student initially assumes that there are right answers to everything and learning is uncovering them. Development begins as a direct response to the realisation that life is not, in fact, like that. Diversity of opinion is first explained as confusion, then as a result of inadequate understanding, before there is the beginning of the realisation that there can be legitimate relativism. From this point, Perry's scheme is concerned with ways in which individuals come to terms with relativism and begin to commit themselves to a particular considered point of view²⁴ (p. 46).

Exploring student designers' ethical development provides important implications for engineering education, in particular, and for socio-technical understandings of design, in general. Understanding student designers' ethical orientation can inform engineering educators efforts to facilitate ethical development within design experiences. As Clarkeburn et al.¹⁸ argue, "A misguided understanding of student meta-ethical development can obstruct successful ethics teaching efforts, because this understanding is a prerequisite for higher levels of moral reasoning skills and even moral sensitivity²⁵" (p. 444). In other words, students who orient to earlier stages of ethical development (i.e., right or wrong) may not be able to truly appreciate or understand the complexity involved with pluralistic understandings of design. As such, engineering educators, based on findings such as those presented in the current study, can find ways to structure design experiences to better meet the ethical orientations of their students. For instance, engineering educators who identify students early in ethical development may be able to facilitate discussions aimed at revealing the many possible ethical approaches in a particular design scenario. By doing so, the students are carefully led from dualistic approaches of ethics in design to more comprehensive understandings.

Investigating student designers' ethical development also provides implications for a socio-technical understanding of design. Bucciarelli²⁶ has pointed to the implications values play in shaping the technologies designers develop. Values in design are represented "in the everyday thoughts, expressed beliefs, and practice of participants²⁶" (p. 185). In the case of the current study, ethical orientations are manifest in designers' everyday thoughts, beliefs, and practices. Designers' ethical orientations suggest how they view their design experiences and what is considered moral or not. Design, as a collaborative enterprise, therefore, consists of multiple agents with multiple ethical orientations that may conflict in how design is understood and ultimately performed. This study provides a more contextualized story of design as socio-technical. That is, we describe moments of ethical development, HCD understanding, and the possible contextual influences that shape them.

Methodology

To describe the emergent nature of ethics and HCD over time, we implemented a longitudinal, qualitative case study focusing on two individual team members of a student design team at a large public Midwestern university across two distinct time points. The cases used for this study included each time point per team member – or a total of four distinct cases. These cases were selected as a subset of a larger qualitative data pool to develop an initial understanding of the emergent nature of ethics and design. Case study research can be broadly categorized as either exploratory, explanatory, or descriptive⁷. Case studies are particularly useful for exploring

complex social phenomenon as they occur in real-life contexts⁷. As such, a case study approach serves as an ideal method given this study's focus of *describing* the relationship between students' ethical orientation and understandings of HCD, and contextual features that shape both.

Participants

The two individual participants chosen for this study's case study analysis were members of a service learning, project-based engineering design program at a large public Midwestern university. Students of this program work in multidisciplinary project teams to deliver solutions to real-world problems. The program includes various classes that work with a community partner to address real-world problems. The classes are facilitated by a mix of professional engineers, engineering educators, as well as faculty in other disciplines with relevant experience. Each class typically holds two to three individual project teams normally comprised of 3 to 9 students from varied undergraduate majors, years in school, and social backgrounds. Projects often range from a number of semesters to several years, with membership changing somewhat between semesters. Students participate as many semesters as they would like and many remain with one project for several semesters, with some staying over the lifetime of their undergraduate careers. Data used in the present study were gathered over the following three semesters: fall 2014, spring 2015, and fall 2015.

The design project

Our study's participants were involved in a design project focusing on developing assistive technology for students who are blind or visually impaired. This project was formally established in fall 2014 and, as such, all members involved in the project during its inception were responsible, to varying degrees, for developing many of the project's goals and initial design outcomes.

Brenda and Brittany

Case study research follows "theoretical sampling" procedures where individual cases are selected because they are particularly well-suited to describe or otherwise highlight the underlying relationships and logics of the emerging phenomenon under study⁵. Cases can be chosen given their unique position to replicate findings, contradict findings, or simply elaborate on an emergent phenomenon⁵. The focal participants of the current study include Brenda and Brittany Bander. Both were undergraduate students within the College of Engineering. Brenda and Brittany were selected given their different experiences with engineering, human-centered design, and with the design project. Although they were members of the same project team during one of the two semesters, their experiences provide contrasting descriptions of their ethical orientations and understandings of HCD. These contrasting descriptions and experiences highlighted the reflexive manner in which ethical development and understanding of design coincide and change over time and in response to different aspects of the design process.

Brenda at the time of her interviews was a freshman, first-year engineering student with intentions of enrolling in the biomedical school. Brenda was one of the project's original team members beginning with the project during the first semester of her freshman year (fall 2014).

She returned to the team the following semester, spring 2015. Brittany at the time of interviews was a sophomore, her first semester on the project (spring 2015), and a junior, her second semester (fall 2015). Brittany was already enrolled in the school of mechanical engineering and had, at the time of data collection, been exposed to some entry and mid-level courses in engineering and design. Additionally, Brittany was previously a member of a different class in the service-learning program. Therefore, she was familiar with many of the procedures and design processes used in the program. As a past member within the service-learning program, Brittany especially had been exposed to designing from a human-centered perspective.

Procedures

In order to capture the emergent nature of ethics in design, we implemented a longitudinal, qualitative case study. We conducted semi-structured interviews across consecutive semesters. That is, each team member, although entering the team at different points in the history of the project, were interviewed at the end of their first semester with the project and again at the end of the second semester on the project. Multiple time points revealed how students' conceptualizations of ethics and of human-centered design emerged concurrently and over time. Interview data represented students' descriptions of their conceptualizations of ethics and morality. This qualitative data also included students' accounts of particular ethical concerns they identified in doing design as well as accounts of how they understood and performed HCD. These descriptions and accounts were analyzed as indications of how ethical reasoning and understanding of HCD developed over time.

Our semi-structured interviews focused on team member relationships, design decisions, and design considerations made in addition to descriptions of any considerations that were raised by other team members. We asked participants to describe, as they see it, the design process their team followed, including asking them to describe the choices the team made along a timeline. For the current study's primary analysis, we focused on students' definition of ethics; what they identified as ethical in design; definitions of human-centered design; and descriptions of how design occurred in their project. Together these conceptual categories pointed to students' ethical orientations and their understanding of human-centered as well as how these experiences were possibly interrelated over time and throughout the design process.

Analysis

We followed a grounded theoretical framework²⁷ for our case study data analysis. Typical case study research involves identification of a "case" or the global topic of interest in addition to the unit of analysis or the source of information⁷. For the present study, the topic of interest included the embedded nature of ethics in design. As such, the unit of analysis involved the individual project team members at two distinct time points as sources of information. Following the constant-comparative method²⁸, we developed categories and coding schemes as they emerged from our data. This process allowed us to draw connections from our data to concepts, such as, how students conceptualized ethics; how students understood human-centered design; and how these conceptualizations changed over time. These conceptual categories were further refined using two frameworks - Perry's^{8,9} schema for ethical development and Zoltowski and colleagues'¹⁰ phenomenographic model of students' understanding of human-centered design.

A significant portion of Perry's schema involves three "meta-ethical development" categories¹⁸ – dualism, multiplism, and relativism. Each category suggests how students orient to basic conceptions of morality; where there are absolute moral answers; what are sources for moral answers; and whether they commit to a particular set of moral values. Analysis involved addressing each of these elements of ethical development to provide a nuanced description and comparison of our participants' ethical orientation and if and how these orientations changed over time. In other words, we used the following considerations from Perry to guide our analysis: *what are students' basic conceptions of morality? do they believe in absolute moral answers? what or who do they identify as sources for moral answers? And do they commit to a set of moral values within a pluralistic world?*

Additionally, Zoltowski et al.¹⁰ provides a comprehensive framework for examining how students understand human-centered design. Similar to Perry's schema, the categories presented in Zoltowski et al., were used as analytic device for describing how students understood HCD. In this paper, findings described the progression of students' conceptualization of ethics and understanding of design; the relationship among the two; and the reflexive relationship each had for understanding how design is practiced within the undergraduate context.

Results

Brenda Bander

Semester 1

Initially, Brenda's understanding of human-centered design reflected those of Zoltowski et al.'s¹⁰ "keeping the users' needs in mind" category. This category of experiences typically attempts to integrate design considerations (i.e., feasibility, desirability, and viability) while keeping the users' needs in mind while designing. Brenda revealed this orientation as she described how she felt users affected the overall design.

- I: And how would you say then the end user...affects your overall design?
- R: Um, it's just keeping in mind things, like when we went to visit the school, you're seeing this technology that's been in these classrooms for 50+ years because there's been nothing else developed, and you're seeing how bulky and big it is. Just, you know, keeping things in mind like, you know, how can we reduce space? And when we went on our visit, seeing how students worked and typed and were communicating with one another, like keeping all of those things in mind, trying to guide our design.

The event of visiting the users was particularly impactful for Brenda's HCD understanding. Proximity to the users, or the context of physically viewing how her users interacted in daily life served as critical moment in Brenda's understanding of design. However, her HCD understanding juxtaposed against a more dualistic ethical orientation revealed a possible tension in developing more comprehensive understandings of design. Speaking to the relationship between ethics and design, Brenda quickly referred to professional standards as a source for moral answers *in* the practice of design.

- I: So overall in engineering design, do you feel like ethics plays a role?
- R: Definitely (laugh). I would say it's, um, well, especially when you're dealing with ethical codes and something that can be accounted back to you, and your name and what you're designing, I think it's very important, especially when it's going to affect a lot of people.

Although codes of conducts and professional standards are critical to the practice of design, they can also limit the ways in which designers seek out information as they attempt to address moral answers. That is, professional standards, in most cases, are established to ensure technical competency but do not embody all ethical considerations designers must contend with (e.g., implications of team dynamics on design, broader societal impact, determining which stakeholders are represented, etc.). The prevalence of professional codes in Brenda's comments may suggest a constraint on her ability to appeal to more pluralistic understandings of morality in design.

Similarly, and following Perry's framework, individuals at early stages of ethical development tend to appeal to authority structures such as those in traditional leadership positions as sources for moral answers. During the first semester interview, Brenda was asked whom on her team she would go to if she had serious ethical concern about the project.

- R: Um, kind of like there's a big problem and there's a lot of conflict within the team individually and [pause] like some of the key players of [pause] I guess who I would trust the most to think about it on both sides and try to understand it more.
- I: Okay. And so then you included Brandon, you included Danny. Any comments?
- R: Just, you know, I see them as like the head of the project and ultimately the ones who are representing us at the forefront, so they're going to try to figure out what's best.

Brenda deferred to authority structures, in this case, team members who were in formal leadership positions. Brandon and Danny were the design lead and project manager, respectively. In this case, given their leadership positions as "representing us at the forefront", Brenda believed her team leaders would be in the best position to resolve ethical dilemmas during the project. Unfortunately, this orientation leaves little room for more relativistic understandings where moral answers may come from various other sources (e.g., team members, stakeholders, users, etc.) based on the context and situation. Brenda's comments were taken during the first semester of the project – also Brenda's first semester on the team. Perhaps Brenda's reliance on traditional authority structures and general ethical orientation was partly shaped by the status of the project – in other words, the context of a newly formed design project.

Although Perry's schema suggests that deferring to authority structures for moral answers is an indication of early ethical reasoning development, the current data set cannot separate other considerations that may confound why Brenda indicated team leaders as sources. For instance, interview responses in and by themselves cannot unpack aspects, such as expertise, in attributing who are sources for moral answers. Our data does, at the very least, suggest the possibilities of early ethical reasoning given Brenda's appeals to those in authority positions. As such, insights

such as these can be a starting point for understanding how ethical reasoning emerges within design teams.

Interestingly, Brenda did reveal elements of more relativistic orientations to ethics and design. When commenting on her criteria for making ethical decisions, Brenda described her experiences in both dualistic *and* relativistic terms. She began by indicating the first things to consider in ethical decision-making were the school and the law, again indicating an appeal to authority structures for moral answers and an early stage of ethical development. However, in the same statement she acknowledged instances where a decision is not always determined by laws or other structures of authority.

R: What are some considerations when making ethical decisions?

I: I would say the first major criteria that really any of us would think about is immediately with the school and the law (laugh), like what can we do, what can't we do, and then it very quickly, since we don't really have any of those instances where we're like, "Well this is going to break the law, so we can't do this," it would be more of like a moral decision, like what do you think would be the better route. You know, it might not technically be something that is wrong, you know, defined by the law or different rules, but it might be something, you know, that's not [pause] you know, it's not on the surface very good, something, you know, kind of on the back burner, a little sneaky.

These comments indicated the fluid nature of how individuals orient themselves in terms of ethical development. That is, individuals typically do not fit nicely into predetermined categories of dualism, relativism, and so on, but rather appeals to ethical reasoning evolve in unpredictable and uncertain ways. This was the case in Brenda's first semester comments where the majority of her ethical appeals came in more dualistic terms while also presenting some recognition of the relativistic nature of morality – and of design.

Semester 2

There were few, if any, changes in Brenda's ethical orientation. She still maintained, for the most part, dualistic descriptions of morality and continued to appeal to authority structures as sources for moral answers in design. Similar to her first semester, Brenda's basic conceptions of ethics were constrained by professional standards and established codes of practices.

I: When you hear the word ethics, what's the first thing that comes to mind?

R: Um, I think of professional ethics [pause] in engineering, like different codes of practice. Just making decisions that are not only morally right but also follow established standards.

Her basic conceptions of morality in her second semester were again potentially limited by professional structures² – in this case established professional standards. Established standards are in place, for the most part, to ensure technical competency but these standards can also neglect other moral considerations in the practice of design. Brenda's response suggests possibilities of professional standards constraining moral understanding in design. However, our

findings do not suggest that these standards were the only contributing factor in her ethical reasoning. Rather, this particular finding simply points to an important consideration engineer educators should account for as they maneuver how ethics is manifested in design.

Although there was not a notable shift in her understanding of ethics, Brenda's view of the users evolved into a more comprehensive understanding of HCD. This was seen as she described how users influenced design and the overall design process.

- I: And how are they influencing your overall design process?
- R: Um, just [pause] well, the user-friendliness. When we started with all the wires in front, you know, cleaning that up, making it so it doesn't impede any of their typing, and just [pause] making it so when they push down on the buttons, they can't really feel that, because they could kinda feel the button presses last semester.
- R: So just making it as easy for them to transition [as possible]. So we just have to kind of just completely try and base design off of that and making it easier for them.

Brenda balanced aspects of feasibility but integrated a more comprehensive understanding of desirability considerations (i.e., the user needs) in design. The main focus was "user-friendliness" while considering functional aspects of the design (i.e., excess wiring, keystroke resistance) that did not impede the students' typing. The shift involved a more comprehensive negotiation of feasibility and desirability concerns. She made design decisions that were rooted in the user-needs (i.e., "not impeding typing"), balancing functionality around these needs. In other words, her descriptions of design suggest a change to a more refined integration of feasibility and desirability concerns. Brenda's descriptions are also an example of the manner in which design processes structure the focus of designers. That is, design processes, such as HCD, to avoid any instance of cognitive overload, focus the attention of designers to certain areas of concern.

Brenda revealed a more comprehensive understanding of human-centered design when expressing the importance of user interaction for design.

- I: Do you feel like it's a...critical point to have members interact with the users versus just hearing secondhand? Do you feel like that plays a role within how you go about the design process?
- R: I think it [does] for sure. And I didn't realize how big of a role it was until I had personally gone to [the user's school] first semester. Because just going into the project and having no idea, not having daily interactions with students that face these kinds of challenges and the kind of classroom dynamic, it's just not something you can imagine on your own. And then [pause] it just kind of emphasized the importance of having the user interaction when we started this semester, and there were people that didn't have that interaction, and I had some of the knowledge but they [pause] it was very, very hard to explain to them what we had seen, and put it into words.

In this response, Brenda revealed the value of interacting with the users. The context of visiting the students and observing the classroom helped her understand the challenges the students experienced on a daily basis. Brenda viewed having an immediate understanding of classroom dynamics as critical to designing, above and beyond being merely told what these dynamics were like. The change is illustrated in the ways she described the value of users in design. Although she mentioned the importance of users in design during her first semester, her second semester comments indicated the *magnitude* of understanding the user in design. Comments such as “it’s just not something you can imagine on your own” indicated a shift in how she described the user and ultimately how she conceptualized their role in design.

Brenda’s second semester comments, in sum, revealed an evolution from a “keeping the users’ needs in mind” orientation to more of “understanding the design in context”. For Brenda, the experience of meeting with and the context of observing students in the classroom provided more of the “why” of a user-need versus the mere discussion of the requirement¹⁰ - a central concern for “understanding the design in context”. Taking Perry’s “meta-ethical” categories into account, over both semesters, Brenda, for the most part, maintained a dualistic orientation toward moral reasoning in design. Her basic conceptions of morality were primarily situated in professional structures, such as, established practices and professional codes which could have limited the scope of moral possibilities in design. Additionally, Brenda appealed to authority structures as sources of moral answers. These authority structures came in form of the legal system, the school, and those in traditional leadership roles. Altogether, the consistency of her descriptions and beliefs over time suggest, comparatively, a fairly entrenched early stage ethical development orientation.

Brittany Bander
Semester 1

In contrast to Brenda, during her first time point, Brittany already appealed strongly to more comprehensive understandings of the user. Following Zoltowski et al., her descriptions of the users in design are similar to those in the “context” category.

R: ...And that’s a big focus for me, is that I don’t want them to have to remove 20 parts and use screwdrivers, because there’s a ton of independently blind people out there who can do everything on their own and they don’t need to call their parents or their friends to come help them put on their shoes and stuff like that every morning.

Brittany balanced desirability and feasibility concerns given what she knew about the user and how she believed the user would use the design within a particular context (i.e., the classroom). The user-need she described involved *independence* for the students. She balanced this need with functional aspects of the design that required elaborate assembly – interfering with the overall desirability of the design. This advanced sensibility toward the user could have been due given Brittany’s previous exposure to engineering and design or also based on the evolution of the project itself. At the time of her first interview, the project had labored through many growing pains of a new project (e.g., establishing user needs, understanding the scope of the project, developing interpersonal team relationships). Given the context of where the project was during

Brittany's interview, the importance of the user may have been more of a central focus for the team in general and thus structuring Brittany's overall understanding of the user and by consequence, of HCD.

Compared to her first semester on the project, in her second semester, Brittany described the users' needs in more elaborate and empathic terms. Her descriptions of the users shifted indicating more comprehensive understandings of HCD. Brittany especially described the users using more emotional appeals. For instance, her comments regarding the importance of students' independence was an example of more empathic descriptions of the user. She considered the possibilities of students feeling overwhelmed or confused given the functionality of the design. Her response was an active negotiation between desirability and feasibility concerns.

R: Because again, if we're making them pull 20 pieces off their Braille to assemble this, that's [pause] that's almost—they either have to be confused, or look for help, or just be a little bit overwhelmed.

For Brittany, balancing design considerations involved a more comprehensive understanding of the user and how the design would affect them within a particular context and in a meaningful way.

Although Brittany demonstrated a broader understanding of contextual concerns in design, some of her first semester responses suggested more of a dualistic orientation to moral answers. This was partially evident in what she deemed as ethical in design.

I: Do you feel like you guys are encountering or have encountered any ethical issues, either on a very small scale, moderate [scale], significant scale?

R: Um, I guess we've—if we've encountered them, we've never really evaluated them. We haven't really been like, "Oh, that's an ethical issue." But I think that's also because we're just really in the beginning stages and we're just trying to get something working.

Brittany's comments implied ethics as static "issues" that exist in some other space able to be identified rather than an embedded process that occurs in the everyday practices¹ of design. Furthermore, Brittany suggested there were not many ethical concerns in her first semester due to the "beginning stages" of the project. Compartmentalizing ethics to distinct phases of the design process suggested a static or absolute view of ethics. Brittany's comments implied there are times of the design process where "ethical issues" are more prevalent. These descriptions therefore partly neglect multiplistic understandings where ethics in design may not occur in the straightforward and predictable ways her comments suggest.

Semester 2

From semester 1 to semester 2, Brittany still compartmentalized issues related to ethics in design. This was evident in her descriptions of the ethical considerations her team faced.

I: So what ethical issues or considerations did you face with this project?

R: Um, I think last semester we faced more, when we were trying to come up with our design and whether or not we were going to have it underneath the keys or inside the Perkins. So that was a choice to treat people who are blind more as people who can sustain themselves versus someone who needs a ton of assistance. So this assistive device is able to be assembled by them, it's able to be attached by them, instead of having one of their sighted friends come over, flip over their Perkins, destroy half the pieces. And so kinda treat people less like they have a disability and more like they have a disability that we can work with versus just reinforcing, like [pause] some assembly required versus no assembly required. So we made choices to design last semester doing that. I'm not sure we've had a ton of ethical choices this semester, just because it has been a technical semester versus [pause] an ethical semester (laugh).

Brittany's descriptions compartmentalized ethics as occurring *last* semester given that semester's more "human-focused" priority. This was in contrast to the *current* semester which focused on the "technical" aspects of the design. Her descriptions of ethics and design denied the possibilities of pluralistic understandings where ethical and technical concerns can co-occur.

However, Brittany did show some change in her ethical reasoning. This was especially prevalent in her definition of ethics. Brittany's definition of ethics acknowledged the possibilities for multiple concerns when resolving moral answers - above and beyond authority structures, such as, established standards or codes of ethics.

I: So as an engineer, how do you make ethical decisions?

R: Um [pause] I think definitely researching or reaching out to whoever your user is. Or [pause] I mean, a lot of people are like, "You should use your code of ethics from your, you know, American Society of Mechanical Engineers," and stuff like that, and I think those are very broad definitions of ethics. Obviously it encompasses a lot of things, like, you know [pause] but it's not [pause] mmm. Within the [service-learning course] world, there's more than just like, is it illegal, is it safe, is it whatever, and it's more on treating the end user as a person versus just the end user.

I: Okay.

R: More than a technical spec. Like more like an actual person.

Brittany's multiplistic understanding of ethics is situated in her focus on the user. That is, focusing on the user forced inclusion of multiple possibilities for the "right" way to proceed in design. This finding suggests the possible relationship between a human-centered focus and higher order orientations in ethical development. Furthermore, the context of the service-learning course possibly shaped this integrated view of ethics and HCD. The course, in her estimation, provided a view of the user that shifted her overall understanding of both ethics and HCD.

It seems that Brittany's evolution in ethical understanding partly co-occurred with a more integrative and iterative understanding of HCD. Similar to her first semester, she balanced desirability and feasibility concerns given her understandings of the user experiences and contextual constraints.

- I: So how do the project partner and the users and potential users affect your design?
- R: Um, well, I think initially they really did. Like, we strayed away from some ideas that came up last semester to have it so that the assembly was—you had to remove part of the Perkins to assemble, and that's just not helpful for Miss Pebblecreek or the students. Somebody who's blind should be able to assemble their own prototype. They should be able to put it in and attach things and it shouldn't be too complicated. And so I think initially we weeded out some of those non-user-focused ideas, and now [pause] it's definitely a priority with the user interface, and it will be, hopefully, more as we keep developing the protoboard insert and making sure everything there is very user-focused."

Her descriptions of how the user affected design revealed the normative assumptions in her understandings of the user. That is, “weeding” out “non-user-focused ideas” was how design should proceed. For her, the balancing of design concerns was guided by a meaningful and contextual understanding of the user. In this case, limiting any added confusion for the students or the teacher and creating independence for both.

Discussion and Conclusions

As with results presented elsewhere, students struggled to identify ethical issues when asked explicitly². However, we saw both a connection between their understanding of HCD and understanding of ethics, as well as their development in both areas. Brenda demonstrated less comprehensive ways of understanding both HCD and ethics as compared to Brittany. The majority of Brenda's comments were situated in an earlier stage of ethical reasoning and as such her descriptions of HCD, according to Zoltowski et al.'s framework, were less comprehensive than Brittany. Findings based on these qualitative data suggested understandings about how ethical reasoning operated in a real-life design setting.

Both Brenda and Brittany developed more comprehensive ways of understanding HCD according to Zoltowski et al.'s¹⁰ HCD model over time. However, Brittany reflected more advanced ways of understanding ethics as related to the Perry Cognitive and Ethical Development model over time, whereas Brenda did not. These results elucidate the messiness of ethics in and by design. Ethical development and understandings of human-centered design do not occur in straightforward and predictable ways for these two students. Rather they developed in a reflexive yet disjointed fashion – evolving in some areas whereas others are anchored in early stages of development.

Previous studies have also found that although a human-centered design process was helpful to orient students to ethical considerations, motives, and decisions, it also limited their ethical concerns to interactions with users². This is evident as well in the experiences and understandings of both Brenda and Brittany. However, we saw in this study the possibilities of how a concern for professional ethics can provide both an awareness, but also a constraint. Professional standards and codes of conduct are vital for engineering and design but can limit the scope of how designers come to understand moral answers; they provide information but also

limit the ways they understand moral aspects of design. This was evident in their general appeal to professional codes as guiding how they think about ethics in design, and not in an integrated way with other concerns.

This study also provides an example of the connection between understanding of HCD and ethics. Students with early stages of ethical development may view their lived experiences in more of a dualistic fashion (i.e., there is a right or wrong answer in any situation). However, the pluralistic nature of design calls for and requires a sensitivity to the possibilities of multiple paths for realizing a desired design outcome. As such, students at early stages of ethical development may find it difficult to grasp the relativistic nature of design and may thus be inhibited from more comprehensive understandings of HCD. Simply put, ethical maturity may anchor or otherwise determine the extent to which individuals progress to higher order and more comprehensive understandings of human-centered design.

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References

1. Goncher, A., & Johri, A. (2015). Contextual constraining of student design practices. *Journal of Engineering Education, 104*(3), 252 – 278.
2. Feister, M. K., Zoltowski, C. B., Buzzanell, P. M., & Torres, D. H. (2016). Integrating ethical consideration in design. *Proceedings of the American Society for Engineering Education Annual Conference and Education, New Orleans, LA.*
3. Case, J.M., & Light, G. (2011). Emerging methodologies in engineering education research. *Journal of Engineering Education, 100*, 186 – 210.
4. Eisenhardt, K.M. (1989). Building theories from case study research. *The Academy of Management Review, 14*(4), 532 – 550.
5. Eisenhardt, K.M., & Graebner, M.E. (2007). Theory building from cases – Opportunities and challenges. *The Academy of Management Journal, 50*, 25 – 32.
6. Yin, R.K. (1994). *Case study research: Design and methods* (2nd ed). Newbury Park, CA: Sage.
7. Yin, Robert K. (2013). *Case study research: Design and methods*. Thousand Oaks, CA: Sage.
8. Perry, W.G., Jr. (1968). Forms of Ethical and Intellectual Development in the College Years: a scheme. San Francisco, CA: Jossey-Bass.
9. Perry, W.G., Jr. (1999). Forms of Ethical and Intellectual Development in the College Years: a scheme. San Francisco, CA: Jossey-Bass.
10. Zoltowski, C.B., Oakes, W.C., & Cardella, M.E. (2012). Students' ways of experiencing human-centered design. *Journal of engineering education, 101*, 28-59.
11. Marton, F. (1981). Phenomenography - Describing conceptions of the world around us. *Instructional Science, 10*, 177-200.

12. Marton, F. (1988). Phenomenography: exploring different conceptions of reality. In D. M. Fetterman (Ed.), *Qualitative approaches to evaluation in education: the silent scientific revolution* (pp.176-205). New York: Praeger Publishers.
13. Mann, L., Radcliffe, D. F., & Dall'Alba, G. (2007). *Using phenomenography to investigate different ways of experiencing sustainable design. Proceedings of the American Society for Engineering Education Annual Conference & Exposition*, Honolulu, HI.
14. Reid, A., & Solomonides, I. (2007). Design students' experience of engagement and creativity. *Art, Design & Communication in Higher Education*, 6(1), 27-39.
15. Daly, S. R. (2008). *Design Across Discipline* (PhD dissertation).
16. Marton, F., & Booth, S. (1997). *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum Associates.
17. Åkerlind, G. S. (2005). Variation and commonality in phenomenographic research methods. *Higher Education Research & Development*, 24(4), 321-334.
18. Clarkeburn, H.M., Downie, J.R., Gray, C., & Matthew, R.G.S. (2003). Measuring ethical development in life sciences students: A study using Perry's developmental model. *Studies in higher education*, 28(4), 443-456.
19. Finster, D.C. (1989). Developmental instruction Part 1. Perry's Model of Intellectual Development, *Journal of Chemical Education*, 66, 659-661.
20. Finster, D.C. (1991). Developmental instruction Part 2. Application of the Perry Model to general chemistry. *Journal of Chemical Education*, 68, 752-756.
21. Gray, C. (1997). *A study of factors affecting a curriculum innovation in university chemistry* (PhD Thesis). University of Glasgow: Glasgow, Scotland.
22. Harvey, J. (1994). *An investigation into ways of encouraging the development of higher level cognitive skills in undergraduate biology students with reference to the Perry scheme of intellectual development* (PhD Thesis). Napier University: Edinburgh, Scotland.
23. Katung, M., Johnstone, A.H., & Downie, J.R. (1999). Monitoring attitude change in students to teaching and learning in a university setting: a study using Perry's developmental model. *Teaching in Higher Education*, 4, 43-59.
24. Lochrie, J.S. (1989). Perry revisited—a fresh look at forms of intellectual and ethical development in the college years. *Studies in Higher Education*, 14, 347-350.
25. Clarkeburn, H.M. (2002). A test for ethical sensitivity in science. *Journal of Moral Education*, 17, 439-453.
26. Bucciarelli, L.L. (1984). Reflective practice in engineering design. *Design studies*, 5(3), 185-190.
27. Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago, IL: Aldine.
28. Lindlof, T. R., & Taylor, B. C. (2011). *Qualitative research methods* (3rd ed.). Thousand Oaks, CA: Sage.