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Exploring Perceptions of Ethics and Social Responsibility Among Engineering Students and Professionals: Research Highlights and Implications for the Field

Brent Jesiek

Dr. Brent K. Jesiek is a Professor in the Schools of Engineering Education and Electrical and Computer Engineering at Purdue University. He holds a B.S. in Electrical Engineering from Michigan Tech and M.S. and Ph.D. degrees in Science and Technology Studies (STS) from Virginia Tech. Dr. Jesiek draws on expertise from engineering, computing, and the social sciences to advance understanding of geographic, disciplinary, and historical variations in engineering education and practice. He is currently Editor-in-Chief of the Journal of International Engineering Education (JIEE) and Director of the National Institute for Engineering Ethics (NIEE).

Stephanie Claussen (Assistant Professor)

Stephanie Claussen is an Assistant Professor in the School of Engineering at San Francisco State University. She previously spent eight years as a Teaching Professor in the Engineering, Design, and Society and the Electrical Engineering Departments at the Colorado School of Mines. She obtained her B.S. in Electrical Engineering from the Massachusetts Institute of Technology and her M.S. and Ph.D. from Stanford University. Her current engineering education research interests include engineering students' understanding of ethics and social responsibility, sociotechnical education, and assessment of engineering pedagogies.

Dayoung Kim (Ph.D. Candidate)

Lazlo Stepback

Carla B. Zoltowski (Assistant Professor of Engineering Practice)

Carla B. Zoltowski is an assistant professor of engineering practice in the Elmore Family School of Electrical and Computer Engineering and (by courtesy) School of Engineering Education, and Director of the Vertically Integrated Projects (VIP) Program within the College of Engineering at Purdue. Prior to her appointment in ECE, Dr. Zoltowski was Co-Director of the EPICS Program. She holds a B.S.E.E., M.S.E.E., and Ph.D. in Engineering Education, all from Purdue. Her research interests include the professional formation of engineers, diversity, inclusion, and equity in engineering, human-centered design, engineering ethics, and leadership.

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Introduction

Ethics and social responsibility are often viewed as key areas of concern for many engineering educators and professional engineers [1], [2]. Yet a growing body of anecdotal and empirical evidence suggests a continuing lack of serious attention to ethics, social responsibility, and related topics in most engineering degree programs (e.g., see [3], [4]). In their systematic review of ethics education in the U.S., for example, Hess and Fore conclude that engineering programs at many universities lack "an explicit focus on students' ethical development" [5, p. 552]. These authors also point to a scarcity of empirical evidence about how engineering students develop ethical and professional responsibilities [5], as well as how perceptions of such responsibilities persist or change in school and at work. The expansive breadth of engineering as a profession raises additional questions about how ethics and social responsibility are understood and experienced in the wide range of disciplines, subfields, and sectors in which engineers practice, including as workplace roles and job demands continue to change and evolve over time [6], [7].

In sum, more work is needed to understand how students and professionals understand and navigate ethical issues, how such perceptions and abilities change over time, and how various kinds of interventions and experiences (e.g., coursework, training, service or volunteer activities, workplace situations, etc.) impact individual engineers. Such objectives seem well aligned with empirical research methods and approaches employed by scholars in engineering education and other social science research fields. Yet conversations around the challenges of conducting rigorous research on engineering ethics are often overshadowed by discussions about the importance and challenges of *teaching* ethics in engineering [2], [5], [8]. We are aware of few if any papers in the science and engineering ethics research field that specifically raise questions around how we define the terms used in our research studies and how we collect and analyze robust quantitative and qualitative evidence related to such concepts. Nonetheless, such questions have tentatively started to surface in some prior conversations among researchers in the field, including briefly at the Ethical and Responsible Research (ER2) Principal Investigator (PI) Meeting organized by the National Science Foundation in 2021 [9].

Looking to other scholarly communities, one particularly relevant discussion regarding the methodological challenges of research on ethics was presented by McLeod et al. in the area of organizational and business ethics [10]. These authors conclude that business ethics "is difficult to define and measure because the perception of ethics varies extensively" [10, p. 440] based on cultural and institutional contexts; that it can be difficult to get research participants to honestly answer questions about ethics due to social pressure; and that ethics is often concerned with

individual behaviors, making it difficult to ask questions about organizational or society-wide ethical judgements. As they further note,

> Ethics are difficult to ascertain and understand since they are abstract, riddled with biases, constantly evolving, and inherently nested across levels of analysis. Each of these reasons individually and collectively demonstrates the uniqueness of the methodological challenges found in organizational ethics research. Taken together, such limitations inhibit organizational ethics research from realizing its full potential. [10, p. 440]

Researchers who study professional ethics will likely find some resonance in these remarks. In this paper, we hope to seed further discussion and exploration around the kinds of issues raised by McLeod et al., albeit in relation to research on the teaching and practice of engineering ethics rather than organizational or business ethics. We begin our discussion by giving a high-level overview of a sequential pair of research studies on engineering ethics and social responsibility led by members of our team, followed by a summary of key research findings that have emerged so far, including quantitative and qualitative results that have been published or are still under review. The second part of the paper delves into a variety of theoretical and methodological questions and challenges that have become apparent in our own research efforts. We examine differing definitions of engineering ethics, social responsibility, and related constructs, the challenge of measuring such dimensions and constructs, and the benefits and practical limitations of both quantitative and qualitative data for exploring research questions in this field. We believe this paper will be relevant for engineering educators and researchers who are interested in measuring and developing ethical capabilities among engineering students and professionals.

Background: Overview of CCE STEM and ER2 Research Projects

As background for the review of findings presented below, we describe here the two sequential research projects our research team has conducted. Our team initially carried out a five year, longitudinal, mixed-methods study to explore engineering students' perceptions of ethics and social responsibility [11], funded by the NSF's Cultivating Cultures for Ethical STEM (CCE STEM) program. This research relied on repeated collection and analysis of quantitative survey measures related to ethics and other relevant constructs [12], [13] and qualitative interview data to explore how students' perceptions changed across time, between institutions, and through participation in certain experiences [14]–[16]. As illustrated in Figure 1, this study involved deploying a variety of survey measures to undergraduate engineering students at four institutions at three different time points. We also conducted interviews with a purposeful sample of the survey respondents, ultimately resulting in longitudinal interview data (collected in their first and fourth year) from 33 total students.

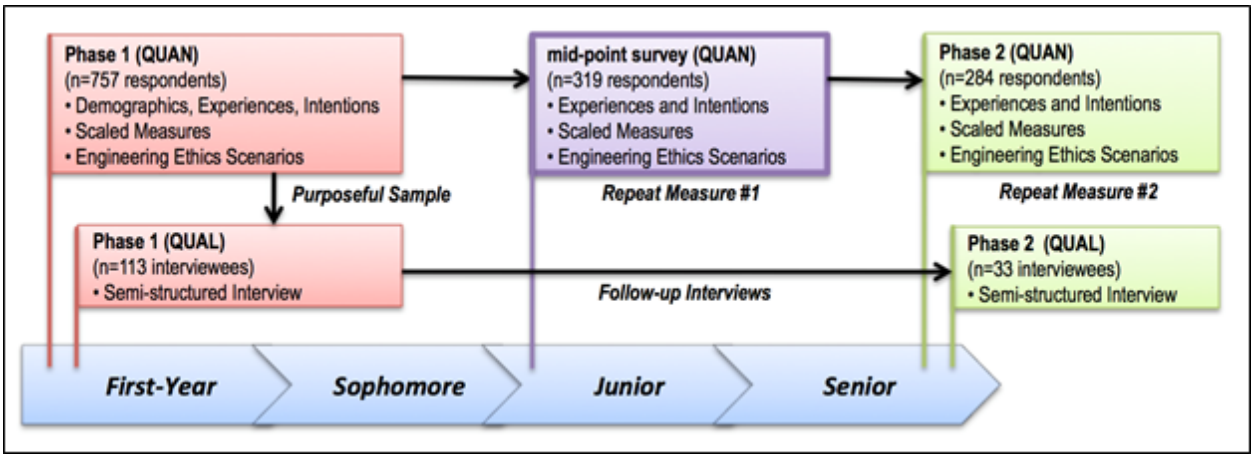

Figure 1. Mixed-methods study design and data summary for initial CCE STEM research project

Additionally, we initiated a follow-on study which is currently underway (see Figure 2) where we are collecting survey and interview data from our previous participants now that most of them are in full-time job roles and/or pursuing graduate degrees, as well as from a new group of early career engineers to enlarge our sample [17]. This study is funded by the NSF's Ethical and Responsible Research (ER2) program. The prior survey respondents will be asked to complete a fourth repeat survey, and interviews will once again be conducted with a purposeful sample of these longitudinal respondents. Additionally, we will collect additional survey and interview data from a new sample of professionals and graduate students so that we can better: 1) compare findings across different industry sectors and engineering disciplines, and 2) conduct robust analyses for various survey measures that were revised or added for the ER2 project. For those wishing to learn more about either of these two studies, we recommend previous papers that describe our study designs and methods in much more detail [11], [17], [18].

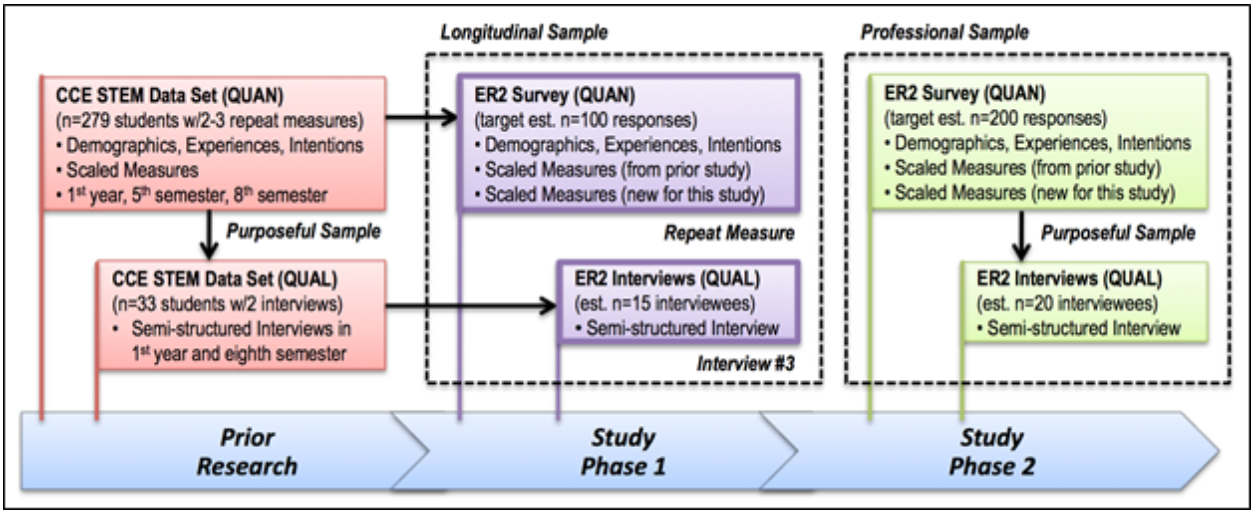

Figure 2. Expanded study design and research plan for follow-on ER2 research project

Part 1: Summary of Previous Findings

The results summarized below are drawn from the first of the two aforementioned projects (CCE STEM), which used a longitudinal, mixed-methods study design to investigate student perceptions of engineering ethics, social responsibility, and related concepts. In brief, these results center on repeat survey responses from students (namely, complete sets of three survey responses from n = 226 students after data cleaning, filtering, etc.) collected during their first, fifth, and eighth semesters of enrollment in undergraduate engineering degree programs at four different universities. The qualitative findings referenced in this paper are focused on pairs of interviews conducted with engineering students (n = 33), recruited from the same pool of survey respondents, during their first and fourth years of undergraduate study.

Our quantitative analysis looked at two overarching questions. First, we explored how students' perceptions of ethics and social responsibility changed over the four years of an engineering degree program [12]. These perceptions were measured by five survey instruments focused on diverse aspects of ethics and social responsibility. We found modest but statistically significant improvements over the first four years of students' undergraduate engineering studies in terms of their ability to respond to situations calling for ethical knowledge and judgment. Further, we did not find evidence of an increase in social or moral disengagement. Students also consistently ranked "health and safety" across time as the most important consideration for engineering work and practice. This consistency in their social consciousness scores as well as their stable results on a Moral Disengagement measure offer some hope that most engineering students are maintaining concerns for public welfare and engagement during their undergraduate years. These results also to some extent contrast with Cech's research pointing to a "culture of disengagement" in undergraduate engineering programs that may negatively impact students over time [19]. Our longitudinal results suggest that students seem to maintain or even slightly increase in their commitments to public welfare and their understandings of ethical practices.

Additionally, our quantitative analysis allowed us to explore how students' perceptions of ethics and social responsibility changed in relation to their participation in a diverse set of experiences such as formal ethics instruction, service learning, internships, etc. [13]. When we compared groups of students – those who did and did not participate in various experiences – we saw no interaction effects for most measures and types of experiences. We hypothesize this reflects a pattern of self-selection into different types of learning experiences. Our findings suggest the difficulty of developing impactful ethics interventions, given that students arrive at university with pre-existing knowledge and perceptions about ethics, morality, and social responsibility, and may opt into experiences and programs that align with rather than challenge their existing values and social commitments.

Nonetheless, through interviews we had multiple opportunities to ask participants about their learning experiences related to morality, ethics, and associated concerns. In a series of papers, we leveraged this data to explore the different kinds of experiences mentioned, along with what students described learning [14], [15], [20]. More specifically, of the seniors who we interviewed (n = 33), more than two thirds described relevant learning in each of the following contexts: internship/co-op settings, academic coursework, and/or family. Further, our results suggest that work experiences were especially significant for students' informal and unstructured learning of engineering ethics in professional settings, followed by academic experiences as a source of both professional/ethical and more general moral lessons. Many students also described family and friends as influencing their general perceptions of morality. Delving deeper into the results, we observe many instances where student learning across these various settings is aligned with or complementary to widely accepted professional codes and other expectations for conduct, but also note a lack of reference to some specific ethical concerns (e.g., public understanding of engineering and technology, not maligning other professionals, etc.), as well as many missed opportunities for employers and educators to better scaffold and link ethics learning within and across different contexts (e.g., school, work, extracurricular and personal experiences, etc.). These results begin to reveal a gap between what can be detected using relatively coarse survey measures and what can be detected using in-depth interviews. This latter source of qualitative data proved very fruitful in revealing the what and where of ethics learning.

As part of our qualitative analysis efforts, a longitudinal thematic analysis of interview data was also conducted using the lens of reflexive principlism [21]. Reflexive principlism is an approach to engineering ethics education which "focuses on internalizing a reflective and iterative process of specification, balancing, and justification of four core ethical principles in the context of specific cases" [21, p. 275]. Those four principles are beneficence, non-maleficence, respect for autonomy, and justice. Our initial comparison of student interviews from the beginning and end of their undergraduate degrees showed a few common themes that were in line with the principles of reflexive principlism as well as other aspects of the framework, such as specificity of responses and balancing of values. The principles of non-maleficence and beneficence were the most frequently mentioned and most central to the interview participants' responses, which is expected given how engineering is often focused on safety and the development of new technology. However, the principles of respect for autonomy and justice were less frequently discussed. Another important aspect of reflexive principlism present in the interviews was the change in how students specified and balanced ethical situations. Our preliminary results show that as students neared the end of their degree programs, most of them were able to use more specific language grounded in their engineering experience as opposed to vague answers that are not related to engineering. Additionally, the students' ability to balance ethical values and stakeholder needs increased across the two interviews.

To better understand the different ways in which students experience ethics and social responsibility, we also used a phenomenographic approach to analyze the data from our second set of interviews. Phenomenography is a qualitative research method in which the "unit of phenomenographic research is a way of experiencing something […] and the object of the research is the variation in ways of experiencing phenomena" [22, p. 11]. Aligned with this methodological approach, we included additional questions in the second interview protocol to explore the qualitatively different ways in which the students experienced engineering ethics. The initial prompt was: "Can you describe an experience you have had with an ethical situation as an individual, student, and/or an aspiring professional?", which was followed by a series of questions to elicit more discussion of the participant's experience of the ethical situation. Using phenomenography, we have identified 8 categories that together capture the diverse ways our participants experienced ethics and social responsibility. These categories are organized along two axes: one focused on the context described by the student, ranging from the very local (micro) to society-wide (macro), and a second reflecting the different ethical frames through which the experience was viewed (e.g., relativistic versus pluralistic). We are developing a separate journal paper where we present detailed findings from this data analysis effort.

Part 2: Conceptual/Theoretical Discussion

In this second part of our paper, we describe a variety of methodological challenges involved in studying engineering ethics which have become increasingly visible to our research team over the course of conducting these two aforementioned research studies. These challenges center on a pair of vexing questions: how do you define ethics (and/or related concepts, such as morality, social responsibility, etc.), and how do you measure individual perceptions and competencies related or central to ethics? In grappling with these challenges, other researchers have created and used many different tools and instruments for studying various facets of ethics, morality, and related constructs. Table 1 lists some of the tools commonly used in studies of engineering ethics. The asterisks indicate the tools/measures that we have used in our own projects. As shown, these can in turn be categorized based on whether the tool is: general or situated in an engineering context; "dimensional" or "compositional" in measuring discrete characteristics, attributes, perceptions, etc. versus developmental tools which typically report a score that maps onto a continuum or different stages/levels of performance; and finally, the specific measurement focus or type of construct associated with each instrument.

This overview suggests at least two key take-aways. First, engineering ethics is a multifaceted and complex phenomena, and the instruments shown here can only glimpse how it is variously experienced and perceived by individual engineers. Even some of the more robust measures (e.g., DIT-2 or EERI) can only give us clues about individual levels of moral development and associated reasoning skills, which may be a very limited view without considering other factors like moral awareness and motivation, the influences of organizational or educational culture,

Table 1: Summary of some of the instruments available to study aspects of ethics and morality

Measure	**Context**	**Paradigm**	**Measurement Focus or Construct**
Fundamentals of Engineering (FE) [23], [24] and Situational Judgment (SJ) [12] items*	Engineering	Dimensional	Engineering ethics knowledge and situational judgment
Ethical Climate Index* [25]	General	Dimensional	Perception of ethical climate in an organization
Moral Attentiveness* [26]	General	Dimensional	Moral awareness and sensitivity
Moral Disengagement* [27]	General	Dimensional	Behavioral propensity based on perceptions of moral disengagement mechanisms
Moral Foundations* [28]	General	Dimensional	Endorsement of moral foundations that impact moral decision-making
Political and Social Involvement Scale (PSIS)* [29]	General	Dimensional	Perceived importance of political/social activities in one's own life
Engineering Professional Responsibility Assessment (EPRA) [30]	Engineering	Dimensional	Attitudes toward social responsibility
Defining Issues Test 2 (DIT-2) [31]	General	Developmental	Moral development and reasoning skills
Engineering Ethical Reasoning Instrument (EERI) [32]	Engineering	Developmental	Moral development and reasoning skills

* Measure/construct employed in one or more phases of our longitudinal study

mechanisms of moral disengagement, etc. Even the sharper focus of ABET Criterion 3.4 on preparing students "to recognize ethical and professional responsibilities in engineering situations, "make informed judgments," and "consider the impact of engineering solutions in global, economic, environmental, and societal contexts" implies at least three partially distinct

outcomes [6]. Further, there remains a lack of validated assessment tools that align with this ABET outcome space.

On a second and closely related point, we continue to lack a more comprehensive or coherent theoretical model or framework for investigating, teaching, and studying engineering ethics. Indeed, one goal of this paper is to initiate a conversation around what such a framework or model might include. The aforementioned ABET outcomes offer one tentative starting point, suggesting that students should develop an awareness of ethical issues, ability to make sound decisions when encountering ethical concerns, and ability to analyze the impacts of engineering work. But again, there remains a lack of clarity regarding how these outcomes are theoretically related to one another, not to mention how they are linked to a wider variety of other individual and organizational characteristics that are likely relevant to the ethical dimensions of technical work. In light of these points, it is perhaps not surprising that we and other scholars have struggled to collect robust empirical data that strongly supports all of our questions, a challenge further compounded by our desire to investigate how students and professionals understand and experience ethics and social responsibility both on a day-to-day basis and on their own terms.

To further delve into these points, our use of a mixed-methods study design revealed the strengths and limitations of employing quantitative and qualitative methods to explore questions of ethics and social responsibility. The quantitative survey measures we used included a variety of survey items and instruments, many of which had been previously used and validated. This enabled us to compare our results to those of other studies and contexts. These quantitative measures were also easy to scale to a large number of participants ($n = 226$ participants responded to all three surveys administered over the four years of our study) and allowed us to make comparisons across demographics such as gender, university, and engineering major. However, as we described above, we found a lack of statistically significant longitudinal changes based on this quantitative analysis. On many of the measures used, we saw little or no change over time, and little or no change in relation to students' participation in certain activities during their time as undergraduates. In short, the quantitative measures were likely not sensitive enough to detect the nuanced ways our students changed over the course of the study.

By contrast, the pair of longitudinal interviews that we used to collect qualitative data in Year 1 and Year 4 of our study proved to be rich sources of insight regarding how participants perceived ethics and social responsibility, and how those perceptions changed over time on the individual level. The interviews were able to detect nuances in student perspectives that could not be detected by the quantitative survey data. However, longitudinal analysis of the interview data has proved very challenging, in part because of the sensitivity of the approach which was also its particular strength. Each pair of interviews is as unique as the participants themselves, which has made it very difficult to scale both the analysis and the conclusions we can draw from the data.

It is further worth noting that our efforts to analyze interview data led us to utilize one existing framework (reflexive principlism) and create a second (phenomenography outcome space), as described in Part 1 of this paper. These findings suggest important future research directions, including theoretical explorations to more deeply think through how these frameworks relate to one another and the wider variety of concepts and constructs mentioned elsewhere in this paper. There is also much potential for instrument development work based on the frameworks employed in our study. Indeed, some tentative steps in this direction can be found in prior efforts by Hess et al. to develop an evaluation rubric based on the reflexive principlism framework to assess levels of ethical reasoning reflected in student responses to an ethics case study [33].

Conclusion

Scholarly work on ethics draws from a variety of disciplinary traditions, often linking philosophical considerations with empirical approaches drawn from the social sciences. Ongoing discussions around "the science of ethics," e.g., [34], have in turn offered critical takes on the philosophical and empirical foundations of such work, including how the more normative bent of philosophy interacts with more descriptive scientific efforts. For instance, philosophers are sometimes accused of being detached from the messy realities of daily life, while social scientists are charged with transgressions such as shallow engagement with the philosophical aspects of their work and downplaying human agency in favor of unconscious biases or other idiosyncratic factors [35].

As the preceding account suggests, in our own investigations we have encountered both empirical and philosophical challenges. Regarding the former, we have been prolific in our data collection and publication efforts, but at the same time observe that the quantitative aspects of our work in particular have not been as fruitful or powerful as we initially hoped. This surprised us - given the volume of work on engineering ethics, we thought our project was well-timed to take advantage of prior work developing and deploying suitable measures. But we have come to find that the existing measures still fall short, tending to focus on narrow aspects of ethics and/or lacking sensitivity, especially to pick up changes over time. The qualitative approach, on the other hand, is more sensitive to changes over time – but it is hard to draw broader conclusions from that type of data due to inherent limits on the number of participants we can reasonably engage due to the nature of qualitative research, while also recognizing and respecting the individual uniqueness of each participant.

We also face challenges related to the more philosophical and theoretical aspects of our work. When we pose the question of "what ought engineers do" when encountering ethical dilemmas or situations, the various professional codes might seem a ready resource and guide. And yet, such codes often prove difficult to operationalize in complex, real-world situations, and educators typically turn to a much wider variety of philosophical frameworks and process

models to enrich ethics education. Indeed, among ethics educators we have observed strong and often passionate individual preferences for different frameworks and process models (e.g., those who wholeheartedly embrace virtue ethics over other normative approaches). Further, we are keenly aware of a much wider variety of factors which influence ethical decision-making and outcomes, ranging from individual characteristics to organizational and cultural factors. Any hope for a "science of ethics" must take into account these multi-faceted intersections of the normative and empirical. We hope this paper helps seed conversations around such challenges among engineering ethics scholars.

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