Ways of Experiencing Ethics in Engineering Practice: Variation and Factors of Change

Dr. Carla B. Zoltowski, Purdue University-Main Campus, 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, and Director of the Vertically Integrated Projects (VIP) Program within the College of Engineering at Purdue. 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.

Dr. Nicholas D. Fila, Iowa State University of Science and Technology

Nicholas D. Fila is an assistant research professor in the Department of Electrical and Computer Engineering at Iowa State University. He earned a B.S. in Electrical Engineering and a M.S. in Electrical and Computer Engineering from the University of Illinois at Urbana-Champaign and a Ph.D. in Engineering Education from Purdue University. His current research explores engineering students' experiences with innovation, empathy across engineering education and engineering design settings, design thinking in the course design process, and novel uses of qualitative research methods in engineering education.

Dr. Justin L Hess, Purdue University at West Lafayette

Dr. Justin L Hess is an assistant professor in the School of Engineering Education at Purdue University. Dr. Hess's research interests include exploring empathy's functional role in engineering; advancing the state of the art of engineering ethics instruction; and evaluating learning in the spaces of design, ethics, and sustainability. Justin received his PhD from Purdue University's School of Engineering Education, as well as a Master of Science and Bachelor of Science from Purdue University's School of Civil Engineering. Justin is the 2020 program chair for the ASEE LEES division.

Alison J Kerr, The University of Tulsa

Alison Kerr received a doctoral degree in Industrial-Organizational Psychology from the University of Tulsa. Her research interests include training development and evaluation as explored across a variety of academic disciplines and organizational settings. She is currently working on a number of training projects aimed at developing engineering students on relevant non-technical professional skills including ethical practice and presentation.

Ms. Dayoung Kim, Purdue University-Main Campus, West Lafayette (College of Engineering)

Dayoung Kim is a Ph.D. student in the School of Engineering Education at Purdue University. Her current research interest centers on engineering ethics and social responsibility, and she is specifically interested in cultural influences on engineers' moral formation. She earned her B.S. degree in Chemical Engineering at Yonsei University, South Korea in 2017.

Dr. Michael C. Loui, University of Illinois at Urbana - Champaign

Recently retired, Michael C. Loui was the Dale and Suzi Gallagher Professor of Engineering Education at Purdue University from 2014 to 2019. He was previously Professor of Electrical and Computer Engineering and University Distinguished Teacher-Scholar at the University of Illinois at Urbana-Champaign. He has published articles in computational complexity theory, in professional ethics, and in engineering education research. He currently serves on the Advisory Group for the Online Ethics Center at the National Academy of Engineering. He is a Carnegie Scholar, a Fellow of the IEEE, and a Fellow of the ASEE. Professor Loui was the editor of the Journal of Engineering Education from 2012 to 2017 and the executive editor of College Teaching from 2006 to 2012. He was Associate Dean of the Graduate College at Illinois from 1996 to 2000. He directed the theory of computing program at the National Science Foundation from 1990 to 1991. He earned the Ph.D. at the Massachusetts Institute of Technology in 1980.

Dr. Andrew O. Brightman, Purdue University at West Lafayette

Andrew O. Brightman serves as Assistant Head for Academic Affairs and Associate Professor of Engineering Practice in the Weldon School of Biomedical Engineering. His research background is in cellular biochemistry, tissue engineering, and engineering ethics. He is committed to developing effective pedagogies for ethical reasoning and engineering design and for increasing the diversity and inclusion of engineering education.

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Abstract

Engineering education researchers have identified a lack of alignment between the complexities of professional engineering contexts and the ways that we train and evaluate the ethical abilities and dispositions of engineers preparing for professional practice. The challenges that engineers face as practitioners are multifaceted, wicked problems situated in unique and varied disciplinary and industry contexts. Understanding the variations in ways of experiencing ethics by practicing engineers in these complex professional contexts will support a better alignment between engineering ethics instruction and what students might experience in professional practice. While there is a need for richer and more contextually-specific ethics training for many areas, our initial focus is the healthcare products industry. Thus, our NSF-funded CCE STEM project will enable us to analyze the alignment of relationships among frameworks for ethics education in engineering and the reality of engineering practice within the health products industry. As a first phase, the project has focused on understanding the different ways in which practicing engineers experience ethical issues in the health products industry using phenomenography, an empirical research methodology for investigating qualitatively different ways people experience a phenomenon. In the second phase, we have analyzed critical incidents that potentially cause the variation in experiencing ethics in practice. The findings of these studies are anticipated to serve as a guidepost for aligning educational strategies and developing effective training for future ethical practitioners. In our paper, we present an overview of the study (background and methods), progress to date, and how we expect the results to inform engineering ethics education and industry ethics training.

Introduction

Engineering degree programs recognize that ethics is essential in preparing students for professional practice. However, current efforts in ethics education often "*decontextualizes* ethics practice from the situated contexts in which ethical theories are 'applied'" ([1], p. 667), and thus may not adequately prepare engineers for the types of situated ethical issues they will likely face in practice. The complexity of factors, from corporate cultures, laws and regulations, as well as societal values, combine to create challenging environments in which engineers have to make ethical decisions they may not have imagined when they were training and studying for their careers. Thus, it is not surprising that engineering education researchers have identified a lack of alignment between the complexities of professional engineering contexts and the ways that we train and evaluate the ethical abilities or dispositions of engineers preparing for professional practice [2]-[5]

Thus, our three-year, NSF-funded CCE STEM project addresses the misalignment between current engineering education practices and workforce demands for a more ethically prepared workforce. While this project focuses on the engineering cultures within the health products industry, the application of a new research methodology to analyze ethical engineering practice, and the resulting findings, grounded in a specific industry context, will translate directly to other industries that employ engineers.

Three research questions (RQ) and associated objectives guide our project:

RQ1: What are the qualitatively different ways engineers experience ethical issues in their engineering practice in the health products industry?

Objective 1: *utilize* ***phenomenography*** *to develop* ***a comprehensive framework****, grounded in the lived experiences of engineers, that describes an understanding of ethical engineering in actual practice;*

RQ2: What patterns of individual and environmental factors contribute to or limit an engineer's experience of ethical engineering practice?

Objective 2: *utilize* ***thematic and content analysis*** *to identify* ***factors that influence*** *the formation of a comprehensive understanding of ethical engineering practice;*

RQ3: To what extent are current frameworks of ethics education aligned with a comprehensive and situated understanding of ethical engineering practice?

Objective 3*:* ***analyze the current frameworks and their alignment*** *with the comprehensive understanding and the critical factors in an engineering-specific context and* ***identify the coverage and gaps in cultivating and assessing cultures of ethical engineering****.*

The approach and findings will pave the way for more comprehensive and better aligned ethical training in other STEM fields as well. In turn, a more ethically prepared workforce will lead to more positive social outcomes. In our paper, we present an overview of the study (background and methods), progress to date related to Objectives 1 and 2 above, and how we expect the results to inform engineering ethics education and industry ethics training.

Background

Professional codes are currently among the most common frameworks for understanding and teaching engineering ethics [6]. While codes are recognized as important to understanding ethical practice in specific engineering disciplines and in engineering generally [7]-[9], ethics codes do not address many aspects of everyday ethical practice [10]-[11], such as those surrounding design, development, and testing of emerging technologies, such as those related to macro-micro perspectives [12] and determining who has access to and who/what will be impacted by new technologies [13]-[14].

Moral development and ethical reasoning frameworks have been used also to understand and teach ethics in engineering. For example, the Defining Issues Test, Version 2 (DIT2, [15]), based on a Neo-Kohlbergian framework of moral development [16], is one of the most often used measures of moral judgment among researchers [17], in general, and specifically within engineering [18]-[20]. Reflexive principlism has been described and tested as a framework for ethical reasoning and ethics pedagogy in engineering [5],[21]-[22]. However, ethical reasoning is but one element of ethical engineering practice, and one that does not necessarily lead to ethical behavior. Other components such as wanting to be ethical [6] or moral motivation [22] and ethical confidence [23] may be the most critical, albeit perhaps the most difficult, to target within engineering ethics education [24].

Other models of professional responsibility such as social responsibility [25], social justice [26]-[27], empathy [28], care [29], and ethical becoming [23] have been identified as lenses for understanding ethical engineering practice and for teaching ethics in engineering. However, as Swiestra and Jelsma [30] wrote, "Scanning the [STS] literature on ethical aspects of engineering practice delivered no systematic data about typical ways in which practicing engineers think about their social responsibility" (p. 315). While some research has partially filled this gap most studies have specifically explored the perceptions of social responsibility of engineering students rather than practitioners (e.g., [31]). Recently, engineering educators also explored the area of corporate social responsibility (CSR), a framework to conceptualize social responsibility of industry [32] so that it more directly relates to ethics in workplaces. However, still how engineers experience ethics in practice is largely unstudied.

The three Objectives of our study aim to address that gap. In the following sections we provide an overview and progress of Objectives 1 and 2 and future work.

Objective 1 Overview and Progress

For Objective 1, we are using phenomenography to systematically investigate the range and complexity of ways that engineers experience ethics in the cultural and institutional contexts of everyday engineering research and practice [33],[34]. Because phenomenography is a qualitative research methodology which explores the ways in which a phenomenon is experienced, it is an ideal method for examining the embedded values and the range of ways that engineers understand and respond to ethical issues in their practice. Ethical engineering practice, for example, is a complex phenomenon involving multiple variations in ways of experiencing ethical problems in actual engineering contexts, where the focus is on engineers as people who act (e.g., become aware, understand, learn, explore, reason, decide, and act) rather than on the actions of engineers (e.g., cheating, being honest, taking responsibility, hiding, bribing, whistle-blowing). Phenomenography differs from phenomenology, which emphasizes individualized meaning making [35]. Phenomenography has been used widely in educational research [36], and more recently applied to analyze challenging problems in engineering education [37]-[41].

In phenomenographic studies, interviews are the primary form of data collection. The semi-structured interviews explore concrete experiences in which the participants engaged with the phenomenon, as well as general conceptions of the interview. Phenomenographic analysis is an iterative process that involves sorting participant descriptions into explicit categories that represent distinct ways of experiencing ethical engineering, identifying suitability of responses within the current categorization, redefining the categories, describing the relationships between categories, and subjecting the categories and relationships to collaborative internal and external critique. The results of phenomenographic research form an outcome space that contains (i) categories of description and (ii) the structural relationships among them.

Validity and reliability of phenomenography analysis [42] is typically achieved by the following strategies: explicit logic of the system of categorization, confirmation of categorization by external collaborator review, and inter-judge communicability of the descriptions of the outcome space [43].

To capture variety and breadth of the experiences of ethical engineering practice, our research team developed a pre-interview screening survey to select participants [44]. Of the over 100 survey responses, we selected 43 interview participants to ensure variation on several criteria, including years of experience, workplace roles, gender, and academic degrees. We have completed six rounds of phenomenographic analysis. A team approach was used for both data collection and analysis [43]. We have presented our preliminary findings after our initial round to 32 engineering educators and researchers at workshop [45] to seek communicative validation. Our current preliminary findings include six categories along four dimensions of variation. Recently, we have received additional feedback from an advisory board with expertise in qualitative research, ethics education, and phenomenographic methodology.

Objective 2 Overview and Progress

In parallel to Objective 1, our research team has been identifying critical incidents which represent key experiences that lead to growth of or solidification in ways of experiencing engineering ethics. While our original plan was to utilize a content analytic approach, we slightly revised our Phase 2 course of action. Specifically, we applied Critical Incident Technique [46], a strategy that members of our team utilized in two recent studies [47],[48]. Critical Incident Technique seeks to identify aspects that were especially pertinent for promoting or reinforcing learning of some phenomenon. The strategy involves reducing data to a set of critical incidents. We utilized three criteria for incident extraction: (1) a thick description of the incident, (2) evidence of what potentially caused a change, and (3) evidence of what the nature of the change may have looked like. Following extraction, we utilized a thematic analysis approach [49] focused on potential changes.

To date, we have extracted incidents from most interviews and analyzed 25 interviews [50]. One member of the research team led incident extraction and two additional members reviewed and critiqued incident selection. Once we agreed upon the criticality of the set of incidents, a member of the research team led the thematic analysis of the extracted incidents and two additional members reviewed and critiqued themes. Thus far, we have sorted 81 incidents into 25 themes and seven categories. While we anticipate the categories will continue to evolve, we anticipate that we are near data saturation (i.e. the point when analyzing additional data does not lead to changes in findings, see [51]), particularly at the category level. The seven categories of incidents representing potential causes of changes in ways of experiencing ethical engineering practice include: (1) Cultural Immersion, (2) Acting Ethically, (3) Ethical Failures, (4) Interpersonal Encounters, (5) Mentorship and Management, (6) Reflection and Association, and (7) Prior Ethics Training. In addition to a separate ASEE manuscript detailing these results [50], a paper presenting a methodological overview on strategies for pairing phenomenography with CIT is in development [52].

Future Work

Future research related to RQ1 will include (1) finalizing a set of categories; (2) identifying the relationships between categories; and (3) generating an outcome space that presents that categories, their dimensions of variation, and the inter-relationships between categories. This analytic process will be further supported by developing "themes of expanding awareness" which represent key features of each category that manifest in different ways for each category. The finalized outcome space will be presented at the conference. In addition, the review of critical incidents related to RQ2 is ongoing. Future work pertaining to RQ2 will include (1) continuing extracting incidents for all remaining participants, (2) sorting incidents into current themes and categories, and, as appropriate, defining new themes, and (3) disseminating results in a scholarly journal. Finally, RQ3 will seek to identify how Phase 1 and 2 results align with extant theories and frameworks utilized in engineering education.

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