2021 ASEE ANNUAL CONFERENCE
Virtual Meeting | July 26–29, 2021 | Pacific Daylight Time
Paper ID #33278

Early Career Engineers' Views of Ethics and Social Responsibility: Study Overview

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Introduction

Despite recommendations from leading stakeholders for increased attention to ethics in engineering education [1, 2], 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 [3-5]. To address this, organizations like the National Academy of Engineering have taken steps to identify best practices and exemplary programs as "a resource for those who seek to improve the ethical development of engineers at their own institutions" [6]. Recent research in engineering ethics has also aimed to measure diverse aspects of ethics and social responsibility, including students' views of these concepts, what influences their perspectives, and the impacts of specific interventions (see, for example, [7-9]). While such efforts are encouraging, there remains limited empirical evidence about how engineering students develop ethical and professional responsibilities [5], as well as how their perceptions of such responsibilities persist or change as they enter their professional careers.

The school-to-work transition is a period of particular interest given that ethics is consistently perceived as an important competency for practicing engineers by many stakeholders [10], including early career engineers themselves [11]. Further, research indicates that many recent graduates do not feel prepared to handle the complexities faced in a professional setting [11-13]. There is also evidence of differences in how ethics and related concepts are conceptualized and prioritized in different engineering fields, both in higher education and industry settings.

Despite being an important need, there is limited prior work on how different professional contexts influence how early career engineers view and experience ethics and related concerns. Further, very few empirical studies have explored how engineers' views of ethics and social responsibility change (or remain constant) as they transition from undergraduate education to early career professional practice. The study described in this paper is funded through a grant from the National Science Foundation's Ethical and Responsible Research (ER2) Program and strives to fill these gaps through the following three research objectives:

> O1) Characterize patterns of ethical development as engineering students transition from their undergraduate studies to the beginning of their professional careers and/or graduate studies,
> O2) Investigate how prior and current experiences impact early career professionals' understandings of ethics and social responsibility, and
> O3) Identify how professional contexts (including the culture of a specific company or institution, discipline, and/or industry sector) influence early career professionals' views of ethics and social responsibility.

In addition to expanding our current knowledge bases in engineering education, engineering practice, ethics, and social responsibility, findings from this study are intended to help university faculty, staff, and administrators develop and scale more effective interventions with long-term, persistent impacts that cultivate a more socially and ethically responsible corps of future

engineering leaders and change agents. We expect our findings will also be of use to engineering industry and graduate schools, namely by providing empirical evidence of how the cultural contexts of these institutions impact early career professionals' views of ethics and social responsibility.

Summary of Prior Project

The project described in this paper builds on a prior NSF Cultivating Cultures for Ethical STEM (CCE STEM) study in which we collected survey and interview data over four years (2015-2019) to explore how undergraduate engineering students' views of ethics and social responsibility changed during their time as undergraduate students, including understanding variations between institutions and the potential impacts associated with experiences such as service-learning and formal ethics instruction [14,15]. This project generated a large data set of repeat survey responses (n=279 across three different times) and interviews (n=33 across two different times).

Quantitative analysis from this data has resulted in findings about students' perceptions of the ethical climates at their universities and measures of their engineering ethics knowledge and situational judgment [9, 16], their commitments to public welfare and responsibilities [17], and the impacts (or lack of impacts) of specific experiences on students' views [18]. Results from the qualitative analysis showed the connections that first-year students made between their views of ethics, generally, and of engineering ethics [19] and identified what students learned from various ethical situations and experiences [20-22].

These quantitative and qualitative findings together beg the question of how perceptions of ethics and social responsibility change in the school-to-work transition. We now have a large and robust longitudinal data set that we can build upon to better understand the transition from undergraduate education to full-time professional work and/or graduate studies. The work of this project will expand this data set both by continuing to follow the participants from the prior study and by growing the pool of participants to strategically capture a wider variety of professional pathways and experiences. This new study will be timed to capture the perspectives of engineers early in their careers (1-3 years after graduation), contributing to the literature on the formation of young engineering professionals as they potentially renegotiate their understandings of ethics and social responsibility in new workplace and/or school settings.

This new project also complements another current CCE STEM funded project [23]. This other existing project uses a phenomenographic approach to investigate the qualitatively different ways engineers experience ethical issues in their engineering practice in the health products industry, and Critical Incident Technique (CIT) to identify patterns of individual and environmental factors that contribute to or limit an engineer's experience of ethical engineering practice.

Study Design and Project Plan

This project builds on our prior work and addresses gaps in the literature by investigating two key research questions:

1) How do perceptions of ethics and social responsibility change in the transition from undergraduate engineering degree programs to the workplace (or graduate studies)?
    a. How do prior experiences and learning (e.g., during pursuit of an undergraduate engineering degree) influence or shape perceptions of ethics and social responsibility among early career professionals?
    b. How do current professional experiences and learning (e.g., in graduate degree programs and/or in corporate work settings) influence or shape perceptions of ethics and social responsibility among early career professionals?
2) How do perceptions of ethics and social responsibility vary depending on a given individual's engineering discipline/background and current professional setting?

To address these questions, we propose a longitudinal, multiphase mixed-method study design [24] to collect quantitative and qualitative data from early career engineers and graduate students, as presented in Figure 1. A mixed-methods approach is "premised on the idea that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone" [25, p. 18], and uses multiple complementary sources of evidence and their respective contrasting research paradigms. Both phases of research for this study will follow an *explanatory sequential design*, where analysis of quantitative (survey) results informs qualitative (interview) data collection and analysis [26] to more deeply understand the phenomena of interest. Our approach is also *interactive* in that emerging insights from each phase of data collection may lead to adjustments in subsequent efforts, assuming that such changes are not overly disruptive to the overall study design [27]. For example, new survey or interview questions may be added as the study progresses, but only if such changes will likely not bias or skew how participants respond to other questions.

Participants and Recruitment – Phase 1 (Longitudinal Sample)

During the first major phase of the study we will seek to collect data from previous participants in our aforementioned CCE STEM research project. All participants in the prior research study were students enrolled at one of the following institutions: Arizona State University, Brigham Young University, the Colorado School of Mines, and Purdue University. We will invite all 279 past participants to complete a repeat (fourth) survey using the measures described below. We will additionally invite all 33 prior interviewees to complete a third interview, using a semi-structured interview protocol as described below. To achieve our sampling targets, we will collect detailed demographic information to characterize this group and make plans for Phase 2.

Participants and Recruitment – Phase 2 (Professional Sample)

To further enhance our ability to address the research questions for this study, we will carry out a second phase of data collection with a separate group of study participants. With the goal of collecting data from respondents who have somewhat similar backgrounds and levels of experience as compared to the Phase 1 group, we will recruit early career professionals with: 1) a BS degree in engineering (any field, any university), and b) 1-3 years of full-time professional work experience and/or graduate studies. Our estimated target is 200 responses using the same survey as Phase 1. To ensure a representative sample and allow comparison of responses among select demographic groups, special efforts will be made to recruit a survey respondent pool that

is at least as diverse (i.e., in terms of gender and ethnic/racial identity) as the overall demographic composition of the U.S. engineering profession [28, Ch. 3]. Purposeful sampling will then be used to recruit approximately 20 interviewees from this same pool of survey respondents based on those indicating a willingness to participate in an interview.

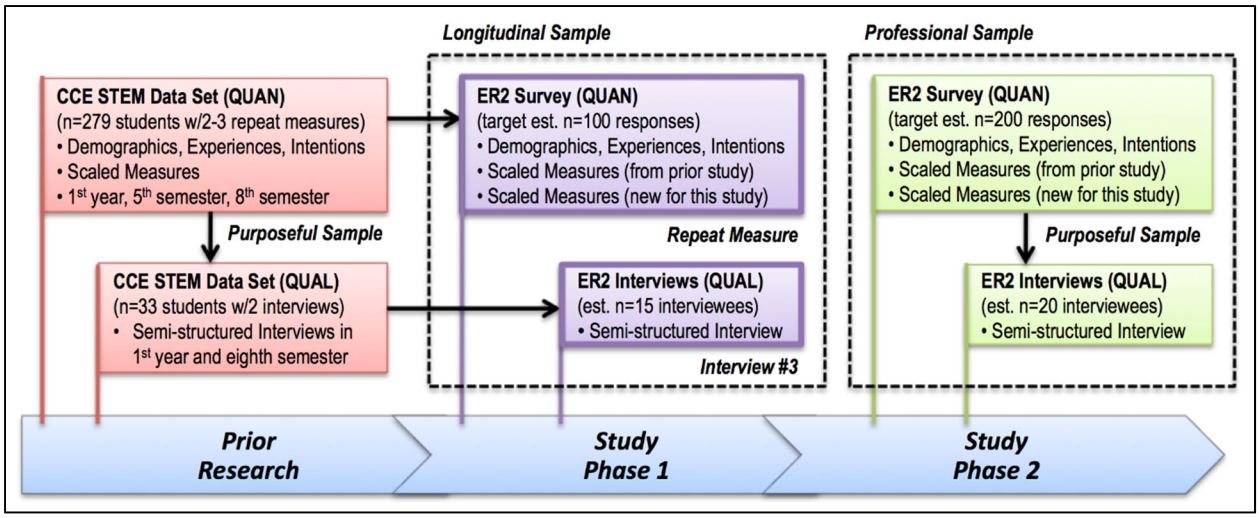

Figure 1. Overview Project Scope and Data Collection Plan

Data Sources

The two sources of data for this project will be surveys and follow-up interviews. Each will be carried out during both of the phases of the study referenced above. Below, we describe these two data sources in greater detail.

Survey Measures

Survey data collection will include eight measures carried over from our previous study [16] and one new measure (the Moral Foundations Questionnaire, or MFQ). These instruments were selected for our research because they reflect a wide variety of complementary constructs and measurement domains and include both general and engineering-specific measures. We added the MFQ to our plan for this study to acknowledge an increasingly "pluralist" view of moral decision-making which involves not only the application of knowledge and reason, but also factors such as moral value commitments [29]. The MFQ is an established 30-item survey that evaluates individual perceptions of morality across five dimensions: harm/care, fairness/reciprocity, ingroup/loyalty, authority/respect, and purity/sanctity [30]. Fifteen of the survey items are evaluated based on relevance, while another fifteen statements related to moral judgment are presented as Likert-scale agreement items.

In addition, we will collect extensive background information from all respondents, including demographic questions for gender identity, race/ethnicity, citizenship, age, prior academic degrees, professional licensure status, etc. Detailed information will also be collected to characterize each respondent's current professional title/role, affiliated organization, work sector, etc. As in our previous research [14], participants will be asked about their religious affiliation

and the perceived importance of religion in their lives. Finally, we will ask about recent and planned future involvement in various activities that may reflect commitments to ethics and social responsibility, e.g., volunteering, mission trips, participating in Engineers Without Borders (EWB) or similar organizations, other professional society activity, etc.

Interview Plan

A semi-structured interview protocol will be used to collect qualitative data from study participants. The protocol will be similar to that used during prior interviews, making it easier to reuse prior analytic tools (e.g., codebook) and compare results across the longitudinal data set. More specifically, we will ask participants questions related to: 1) their personal and professional background, 2) experiences with ethics and social responsibility, 3) general definitions of ethics and engineering ethics, including social responsibility and other macro-ethical considerations, 4) experiences (past, present, and future) that may have shaped their ethical perspectives and sense of social responsibility, 5) perceptions of ethical climate in their current organization, and 6) select survey items identified as promising for further probing. The second section of our interview aims to more specifically explore the qualitatively different ways in which participants experience ethics. To elicit such perspectives, the initial prompt for this part of the interview is: "Can you describe an experience you have had with an ethical situation as an individual and/or practicing professional?" In turn, a series of questions will be used to elicit more discussion of the participant's experience of a given situation. This portion of the interviews will be analyzed using the phenomenographic approach outlined below.

Data Analysis Plan

Quantitative

During Phase One, we will first match new survey data with each participant's responses to the Year 1 (2015) and Year 4 (2019) surveys, for a total of three complete sets of measures for each respondent. Some students will have responded to all three original surveys (2015, 2017 and 2019), with the new survey serving as a fourth repeat measure. This longitudinal data set will allow us to analyze intra-individual changes over time. Analyses will include repeated-measures ANOVA, split-plot ANOVA, and relevant non-parametric statistical techniques depending on the types of data and sample sizes [31]. Additional analyses may include multiple regression and structural equation/multilevel modeling [32-34]. These analyses will allow us to see change in various measures over time (or possibly a lack thereof), including in relation to other variables such as demographic characteristics, involvement in certain kinds of activities, etc.

For Phase Two, as new data is gathered on the same scales from new participants, it will be pooled with the survey responses collected during Phase One. This combined cross-sectional dataset will allow comparison between different groups (specifically, demographic groups and participants' employment sectors/contexts). These groups' scores on the scales will be compared using one-way ANOVA and possibly multiple regression. Where sample size is too small for those techniques, non-parametric statistical analyses will be used to compare groups [31].

Qualitative

Our approach to analyzing interview data aims to provide explanatory depth and "thick description" [35] for patterns and trends observed in the quantitative data sets, and allow identification of novel trends and phenomena of interest not readily evident or detectable in other data from this project. Consistent with our prior research efforts as well as the goals of this new study, we will use two distinct approaches to analysis. First, *thematic analysis* [36] will be used to code prominent themes in the data following best practices across the six analysis steps recommended by Braun & Clarke [37]: getting familiar with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and reporting results. Given the study questions and interview protocol, likely themes for this analysis include definitions of social and/or ethical responsibility, types of ethical situations often encountered by professionals, types of learning experiences viewed as most relevant or impactful, changes in perceptions of social and/or ethical responsibility, observations about institutional/organizational culture, etc. This analysis approach is proposed because it allows identification of themes both inductively and deductively [38], while enabling systematic study of similarities and differences in the data, including social and psychological interpretations [37].

Second, as noted above we will also perform further analysis of the interview data using a phenomenographic approach to identify different ways of experiencing ethics and social responsibility among early career professionals. Phenomenography is a qualitative approach in which the "way of experiencing something … and the object of the research is the variation in ways of experiencing phenomena" [39]. Phenomenographic analysis considers each transcript holistically, and is highly iterative and comparative [39-41]. This method has a strong and growing record of use in engineering education, such as research by Zoltowski and colleagues on how students experience human centered design [42].

Integration

One of the most challenging but also most powerful aspects of mixed-methods research involves integration of study findings across the quantitative and qualitative data sets [27]. For this study, integration is reflected across multiple levels, including our choice of a multistage explanatory sequential study design and openness to connecting results and adjusting data collection plans as the research unfolds. For instance, interviewees may be recruited at either stage of data collection based in part on survey results, such as by seeking out individuals who are outliers on particular measures or are from groups that have distinctive response patterns across measures. Integration will also occur during the interpretation and reporting phases of the project, such as through research papers that discuss and interrelate results from both the quantitative and qualitative data analysis.

Summary

This new research project builds upon an existing longitudinal data set from a prior NSF-funded study which followed engineering students through the four years of their undergraduate studies using both quantitative and qualitative research methods. We will continue to follow these participants as they transition into the workplace or graduate studies. Our findings will extend engineering education researchers' understandings of how early career professionals' views of ethics and social responsibility are shaped by their experiences as undergraduates and by the transition from undergraduate engineering education to professional practice. Our project will also expand beyond the longitudinal work to explore the influences of professional contexts and institutional cultures on early career professionals' understandings of ethics and social responsibility.

This work is expected to make numerous intellectual contributions to the existing literature by documenting how young professionals in engineering and related fields view and enact engineering ethics and social responsibility and how these views are influenced by organizational/institutional cultures. We anticipate that our findings will also benefit engineering stakeholders in both academia and industry, namely by generating new insights about what types of learning environments and experiences have the biggest impacts on how engineering students and professionals perceive and practice ethics, social responsibility, and related concerns.

Acknowledgments

These materials are based in part upon work supported by the National Science Foundation under Grant Nos. 1449479, 2024301, and 2130924. Any opinions, findings, and conclusions or recommendations expressed in these materials are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We also gratefully acknowledge the many researchers who contributed to this project since it first started as an NSF CCE STEM study in 2015.

References

[1] ABET, *Criteria for accrediting engineering programs: Effective for reviews during the 2019–2020 accreditation cycle*. ABET, Inc., 2018. Available: http://www.abet.org/.

[2] American Society of Civil Engineers, *Civil engineering body of knowledge: Preparing the future civil engineer* (3rd Edition). American Society of Civil Engineers, 2019. Available: https://doi.org/10.1061/9780784415221

[3] K. D. Stephan, "A survey of ethics-related instruction in U.S. engineering programs," *Journal of Engineering Education*, vol. 88, no. 4, pp. 459–464, 1999. Available: https://doi.org/10.1002/j.2168-9830.1999.tb00474.x

[4] A. Colby and W. M. Sullivan, “Ethics teaching in undergraduate engineering education,” *Journal of Engineering Education*, vol. 97, no. 3, pp. 327–338, 2018.

[5] J. L. Hess and G. Fore, “A systematic literature review of US engineering ethics interventions,” *Science and Engineering Ethics*, vol. 24, no. 2, pp. 551–583, 2018.

[6] National Academy of Engineering, *Infusing ethics into the development of engineers: Exemplary education activities and programs*. Washington, DC: The National Academies Press, 2016. Available: https://doi.org/10.17226/21889

[7] S. Niles, S. Contreras, S. Roudbari, J. Kaminsky, and J. L. Harrison, “Resisting and assisting engagement with public welfare in engineering education,” *Journal of Engineering Education*, vol. 109, no. 3, pp, 491-507, 2020.

[8] D. Kim, S. J. Howland, and B. K. Jesiek, “Engineering students’ learning of ethics: Influences and lessons,” under review.

[9] S. M. J. Howland, G. M. Warnick, C. B. Zoltowski, B. K. Jesiek, and R. Davies, “A longitudinal study of social and ethical responsibility among undergraduate engineering students: Comparing baseline and mid-point survey results,” in *Proceedings of the 2018 American Society of Engineering Education Annual Conference and Exposition,* Salt Lake City, UT, June 24-27, 2018.

[10] H. J. Passow and C. H. Passow, “What competencies should undergraduate engineering programs emphasize? A systematic review,” *Journal of Engineering Education*, vol. 106, no. 3, pp. 475-526, 2017.

[11] S. R. Brunhaver, R. F. Korte, S. R. Barley, S. D. Sheppard, R. Freeman, and H.Salzman, “Bridging the gaps between engineering education and practice,” in *US engineering in a global economy*, R. B. Freeman & H. Salzman, Eds., Chicago, IL: The University of Chicago Press, 2018, pp. 129-163.

[12] L. Lattuca, P. Terenzini, D. Knight, and H. K. Ro, *2020 vision: Progress in preparing the engineer of the future.* Ann Arbor, MI: University of Michigan, School of Education, 2014. Available: https://deepblue.lib.umich.edu/handle/2027.42/107462

[13] J. Trevelyan, *The making of an expert engineer*. Leiden, The Netherlands: CRC Press, 2014.

[14] C. B. Zoltowski, B. K. Jesiek, S. A. Claussen, and D. H. Torres, “Foundations of social and ethical responsibility among undergraduate engineering students: Project overview,” in *Proceedings of the 2016 American Society of Engineering Education Annual Conference and Exposition,* New Orleans, LA, June 26-29, 2016.

[15] C. B. Zoltowski, N. D. Fila, A. O. Brightman, J. L. Hess, D. Kim, M. C. Loui, and A. J. Kerr, "Ways of experiencing ethics in engineering practice: Variation and factors of change," in *Proceedings of the 2020 American Society of Engineering Education Annual Conference and Exposition,* Virtual, June 22-26, 2020.

[16] C. B. Zoltowski, B. K. Jesiek, S. A. Claussen, S. J. Howland, and D. Kim, "Foundations of social and ethical responsibility among undergraduate engineering students: Overview of results" in *Proceedings of the 2020 American Society of Engineering Education Annual Conference and Exposition,* Virtual, June 22-26, 2020.

[17] S. J. Howland, B. K. Jesiek, S. Claussen, and C. B. Zoltowski, "Measures of Ethics and Social Responsibility Among Undergraduate Engineering Students: Findings from a Longitudinal Study," under review.

[18] S. J. Howland, S. A. Claussen, B. K. Jesiek, and C. B. Zoltowski, "Influences on Undergraduate Engineering Students' Perceptions of Ethics and Social Responsibility: Findings from a Longitudinal Study," under review.

[19] B. K. Jesiek, C. B. Zoltowski, D. S. Fuentes, S. Claussen, and G. M. Warnick, "Investigating engineering students' understandings of social and ethical responsibility: coding framework and initial findings," in *Proceedings of the 2017 American Society of Engineering Education Annual Conference and Exposition,* Columbus, OH, June 24-28, 2017.

[20] D. Kim, S. J. Howland, and B. K. Jesiek, "Engineering Students' Learning of Ethics: Influences and Lessons," under review.

[21] S. Claussen, S. J. Howland, S. Nittala, C. B. Zoltowski, and B. K. Jesiek, "Longitudinal Qualitative Case Study of an Engineering Student's Perceptions of Ethics and Social Responsibility: Corvin's Story," in *Proceedings of the 2021 American Society of Engineering Education Annual Conference and Exposition*, Virtual, July 26-29, 2021.

[22] D. Kim, S. J. Howland, and B. K. Jesiek, "Encountering Engineering Ethics in the Workplace: Stories From the Trenches," in *Proceedings of the 2021 American Society of Engineering Education Annual Conference and Exposition*, Virtual, July 26-29, 2021.

[23] A. O. Brightman, N. D. Fila, J. L. Hess, A. J. Kerr, D. Kim, M. C. Loui, and C. B. Zoltowski, "Applying phenomenography to develop a comprehensive understanding of ethics in engineering practice," in *Proceedings of the 2018 IEEE Frontiers in Education Conference (FIE),* San Jose, CA, October 3-6, 2018.

[24] J. W. Creswell and V. L. P. Clark, *Designing and conducting mixed methods research* (2nd Edition). SAGE Publications, 2011.

[25] J. W. Creswell and V. L. P. Clark, *Designing and conducting mixed methods research* (1st Edition). SAGE Publications, 2007.

[26] J. W. Creswell, "Revisiting mixed methods and advancing scientific practices," in *Oxford Handbook of Multimethod and Mixed Methods Research Inquiry,* S. N. Hesse-Biber and R. B. Johnson, Eds., New York, NY: Oxford University Press, 2016, pp. 57-71.

[27] M. D. Fetters, L. A. Curry, and J. W. Creswell, "Achieving integration in mixed methods designs—principles and practices," *Health Services Research*, vol. 48, no. 6, pp. 2134-2156, 2013.

[28] National Science Board, "Science and Engineering Labor Force," in *Science & Engineering Indicators,* 2018. Available: https://www.nsf.gov/statistics/2018/nsb20181/report/sections/science-and-engineering-labor-force/highlights

[29] R. F. Clancy and H. Hohberger, "The moral foundations of Chinese engineering students: Preliminary investigation," in *American Society of Engineering Education Annual Conference and Exposition,* Tampa, FL, June 15-19, 2019.

[30] J. Graham, B. A. Nosek, J. Haidt, R. Iyer, S. Koleva, and P. H. Ditto, "Mapping the moral domain," *Journal of Personality and Social Psychology*, vol. 101, no. 2, p. 366, 2011.

[31] S. G. Heeringa, B. T. West, and P. A. Berglund, *Applied survey data analysis*. Boca Raton, FL: CRC Press, 2010.

[32] T. Z. Keith, *Multiple regression and beyond: An introduction to multiple regression and structural equation modeling* (2nd Edition). New York City, NY: Routledge, 2015.

[33] J. Wang and X. Wang, *Structural equation modeling: Applications using Mplus*. West Sussex, UK: Wiley, 2012.

[34] T. D. Little, *Longitudinal structural equation modeling.* New York City, NY: Guilford Press, 2013.

[35] M. Geertz, "Thick description: Toward an interpretative theory of culture," in *Readings in the philosophy of social science*, M. Martin and L. McIntyre, Eds., Bradford, 1994, pp. 213-232.

[36] R. E. Boyatzis, *Thematic analysis and code development: Transforming qualitative information.* London and New Delhi: SAGE Publications, 1998.

[37] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77-101, 2006.

[38] J. Fereday and E. Muir-Cochrane, “Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development,” *International Journal of Qualitative Methods*, vol. 5, no. 1, pp. 80-92, 2006.

[39] F. Marton and S. Booth, *Learning and awareness*. Mahwah, NJ: Lawrence Erlbaum, 1997.

[40] G. Åkerlind, “Phenomenographic methods: A case illustration,” in *Doing developmental phenomenography*, J. A. Bowden & P. Green, Eds., Melbourne: RMIT University Press, 2005, pp. 103-127.

[41] J. A. Bowden and P. Green, *Doing developmental phenomenography.* Melbourne: RMIT University Press, 2005.

[42] C. B. Zoltwoski, W. C. Oakes, and M. E. Cardella, “Students’ ways of experiencing human-centered design,” Journal of Engineering Education, vol. 101, no. 1, pp. 28-59, 2012.