Exploring Ethical Motivation in an Undergraduate Engineering Ethics Course

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***Abstract*— This Work-in-Progress Research paper investigates ethical motivation in engineering students across a single semester of an interdisciplinary engineering ethics course. Ethical motivation is the process of deciding to act upon an ethical decision based on one's valuing of ethics, as well as one's ability to prioritize moral concerns and professional values over personal interests. To prepare students to prioritize ethical and professional obligations, ethical training needs to help students become aware of, align, and act upon both their personal and professional values. This study operationalizes ethical motivation using Nancy Tuana's moral literacy framework and James Rest's four component model of morality. To assess engineering students' ethical motivation, we collected quantitative and qualitative data from an engineering ethics course offered in Spring 2022. This paper describes the theoretical frameworks guiding this study, the data collection procedures, and the planned data analyses. The goal of this study is to contribute to understanding ethical formation in engineering education. Prior research on ethical formation in engineering has largely focused on ethical judgment and ethical sensitivity. We expand on prior work by exploring the role of ethical motivation in engineering students' ethical formation. Findings from this study will provide insights into how students internalize professional values into their views of engineers' roles and ultimately into their future practice as engineers.**

Keywords—engineering ethics; values; motivation; interdisciplinary engineering; mixed methods research

I. Introduction

Ethical formation in engineering education is an important aspect of the professional formation of engineers. More concisely, ethical formation is the ontological process of becoming an ethical engineer. Thus, research on ethical formation identifies how engineering programs might best prepare students for their ethical responsibilities as engineers.

In this paper, we focus on assessing one aspect of engineering students' ethical formation: ethical motivation. We consider ethical motivation to be the process of deciding to act upon an ethical decision [1]. Ethical motivation includes one's valuing of ethics and one's ability to prioritize moral concerns and values over personal interests [2]. Thus, ethical motivation involves valuing an ethical choice or obligation over competing priorities, such as one's own self-interest. Ethical motivation is an important determinant of ethical behavior, especially in the engineering profession wherein most disciplines provide students and practitioners with explicit ethical and professional obligations and expect that they will act in accordance with these obligations in their future work [3]. To prepare students to prioritize these personal and professional obligations, ethical training needs to help students become aware of, align, and be prepared to act upon their personal and professional values.

II. Theoretical Framework

To define and operationalize ethical motivation, we draw upon Nancy Tuana's moral literacy framework and James Rest's four component model of morality.

A. Tuana's moral literacy framework

Tuana [4], [5] offers a tripartite model of moral literacy. Tuana [4] equates moral literacy with other literacy modalities emphasized by the U.S. Department of Education for K-12 students. The U.S. national agenda has emphasized certain types of literacy, such as reading, science, and foreign language, but has historically omitted moral literacy. An emphasis on moral literacy is imperative to American citizen development, as well as (we would argue) engineers' ethical formation. Tuana [4] defines literacy as "the skills and knowledge specific to making ethical choices in life" (p. 365). Similarly, we would define *engineering* moral literacy as the skills and knowledge specific to making ethical choices in engineering. Tuana [5] updated her initial model [4] and offered three primary interconnected components for moral literacy, each with numerous sub-components, including:

1. **Ethics sensitivity,** or the awareness of or ability to identify ethical issues, values, or virtues that are salient to a situation
2. **Ethical decision-making**, or the ability to assess ethical situations using ethical frameworks and by considering individual and group values
3. **Ethical motivation**, or the purpose, courage, and hope to act on one's ethical intentions and perceptions [5]

Tuana [5] emphasizes that developing moral literacy requires integrating these three components and their numerous subcomponents. These three components of moral literacy align with learning objectives of post-secondary engineering education. For example, both ethics sensitivity and ethical reasoning are pervasive in ethics teaching approaches in engineering education [6] and ethics sensitivity is often the first step in ethical inquiry in engineering [7].

B. Rest's four components of morality

Rest's Four Component Model is a neo-Kohlbergian model of moral development [8]. Rest was a student of Kohlberg's who came to challenge Kohlberg's assumption that moral judgment would lead to moral action. Instead, he theorized that moral

judgment processes were important but not sufficient for moral action [1], [2]. To substantiate this claim, he conducted an extensive review of literature in psychology to find empirical studies related to moral action. His goal was to synthesize various theoretical perspectives on the underlying processes guiding moral action. From this synthesis, he proposed four components of morality [1]:

1. **Moral sensitivity**, or one's ability to recognize the moral dimensions or implications of a situation,
2. **Moral judgment**, or one's ability to use moral reasoning to make an ethical decision,
3. **Moral motivation**, or one's ability to prioritize moral concerns and values over personal interests, and
4. **Moral character**, or one's determination and ability to follow through on a moral choice.

Rest's model posits that any moral action could be explained by one or more of these distinct psychological processes [1]. Thus, Rest's model is useful for understanding processes that lead to moral behaviors within a specific context.

C. Applying Tuana & Rest's models to moral development

Tuana and Rest's models both emphasize the co-dependency of discrete but related components of morality. As Tuana [4] writes, "The development of an understanding of ethical reasoning skills can serve to heighten ethics sensitivity" (p. 366). Moreover, Tuana [5] indicates that developing moral literacy requires a focus on all three components. Thus, it is critical to not isolate these key aspects of moral development.

When we look across models, we see commonalities. For example, Tuana and Rest both emphasize sensitivity, cognitive reasoning (i.e., judgement and decision-making), and motivation. The primary distinction is Rest's additional component, character.

Both models are also useful for studying moral behavior because both assume that developing the capacity for sensitivity, reasoning/judgment, motivation, and character will help or enable one to act more ethically. As Tuana [5] writes, "Moral literacy aims, always, at moral agency and action" (p. 172). Thus, these models posit that education can help develop capacities that are essential for and potentially will result in moral behaviors. This emphasis on development is one reason why Rest's model is commonly used to understand ethical formation in professional education [2].

Rest's model is particularly suitable to study moral development in professional education because ethical training is often explicit in professions. Rest's model can be used to assess the impact of ethical training on students' ethical formation. An important aspect of ethical formation is learning the knowledge and skills to perform competently in ways that are aligned with the profession's expectations and values. This also involves learning to internalize the values of the engineering profession into one's own professional practice [9].

Engineering education is a form of professional education that seeks to prepare students for the engineering profession. Ethics is also an explicit outcome of engineering education, and thus Rest's model offers a viable approach for studying moral development among engineering students, including assessing how engineering education affects students' ethical formation.

C. Applying Tuana & Rest's models in engineering education

Tuana's model has received large attention in STEM education but less explicit focus in engineering education. Rest's model, on the other hand, has received explicit attention in engineering ethics education [10]. Of the four components, moral judgment has been the most studied. In particular, many studies on ethical reasoning in engineering have used Rest et al.'s instrument for assessing moral judgment: the Defining Issues Test (versions 1 or 2, DIT or DIT2) [11]–[14]. The DIT and DIT2 have been adapted specifically to engineering in the form of the Engineering Ethical Reasoning Instrument [15].

While moral judgment and moral sensitivity have been well-studied in engineering education, there has been relatively less attention to the other components of Rest's model. Bairaktarova and Woodcock [16] considered Rest's four components of morality in their proposed model for engineering students' ethical awareness and behavior. Their model focused on measuring and teaching ethical awareness, intentions, and behavior rather than instruction and assessment of ethical reasoning.

The predominant emphasis on ethical sensitivity and ethical reasoning in engineering education [6] invites further research on other components of morality, such as moral imagination, motivation, and character. Both Tuana and Rest's models stress the importance of these components as determinants of moral behavior (in addition to moral judgment and moral sensitivity). Rest et al. [8] argue that a failure in any of their four components can lead to unethical behavior. In other words, even if students can reason through an ethical dilemma, they may fail to recognize an ethical issue, fail to be motivated to resolve the issue, or fail to follow through on their plan. Thus, we need a more holistic approach to engineering ethics education that incorporates more than ethical sensitivity and reasoning. This study aims to further this goal by focusing on the third components of Tuana and Rest's models – ethical and moral motivation, respectively – and how motivation manifests in engineering education. To maintain consistent language with Tuana's framework, we will use the term ethical motivation rather than moral motivation in the rest of the paper. We chose the term "ethical" because it is generally used to describe moral issues within a professional context, such as engineering [17].

III. Study Purpose

This study explores ethical motivation in engineering students using Tuana's and Rest's conception of ethical motivation. Though all components in their models of morality are important, few studies have assessed the specific component of ethical motivation in engineering. We aim to address this research gap in this study.

A. Ethical motivation: The moral component of professional identity

Ethical motivation describes the process of deciding to act upon a moral decision. Ethical motivation involves valuing a moral choice or obligation over competing priorities (such as one's own self-interest) [1], [2]. Ethical motivation is an important determinant of moral behavior, especially in a profession like engineering that provides explicit ethical and

professional obligations for practitioners [18]. To prepare students to prioritize engineers' ethical and professional obligations, ethical training needs to instill professional values in students.

In professional education, ethical motivation has been operationalized as the moral component of professional identity. Ethical motivation and professional identity are related through how one views their professional role and responsibilities towards others. One's orientation towards their professional role will influence how they act when facing an ethical situation in their work [9]. The connection between ethical motivation and professional identity has also been framed as professional role identity, which refers to the internalized beliefs one has about their professional obligations, attitudes, and behaviors [19].

Through this lens, ethical motivation represents the process of choosing to prioritize a profession's values, potentially even internalizing these values to a greater extent than one's own prior values. Often, professional values are embedded within codes of ethics, and engineers need to internalize these values to translate them into behaviors. Recognizing this connection, Bebeau et al. [20] proposed that one's professional role identity can potentially depict one's ethical motivation.

B. Assessing ethical motivation and professional role orientation

Professional role orientation has been assessed as a proxy of ethical motivation in professional education through surveys, interviews, and essays [21]. One standardized inventory is the Professional Role Orientation Inventory (PROI), originally developed by Bebeau and colleagues within the dentistry profession [20], [22]. The Professional Role Orientation Inventory consists of 4 subscales, each consisting of 10 items: Authority, Responsibility, Agency, and Autonomy.

Authority and Responsibility are complementary dimensions. When interpreted in tandem, these two scores can reveal how an engineer views their role within society. **Authority** measures the extent to which one values their professional knowledge and feels that their profession should exhibit ownership of professional knowledge and expertise. One who scores high on the Authority dimension is likely to believe their judgments as professionals should be respected. In contrast, one who scores low on the Authority dimension is more likely to value other people's judgments as much as those of professionals and feel that those judgments ought to inform professional knowledge. The **Responsibility** dimension measures one's commitment to others. Someone who scores high on this dimension is likely to emphasize their role in serving the public, especially people who are disadvantaged. In contrast, someone who scores low is likely to believe people can look after themselves. Together, scores across both dimensions lead to four possible characterizations of how one perceives their profession [20], [22]. To illustrate how they manifest within engineering, we describe how an engineer might exemplify each of the four characterizations:

1. **High authority, high responsibility:** Believes engineers have expertise that should be valued but recognizes that it comes with an obligation to use that expertise to respond to societal needs and promote social welfare.
2. **High authority, low responsibility:** Believes engineers have expertise that is valuable to others and seeks to leverage this expertise to gain competitive advantages over others.
3. **Low authority, high responsibility**: Believes engineers have skills that are not afforded to most people and that engineers are obligated to use those skills to serve humanity. They may encourage regulation and public involvement in their work because they believe their profession's purpose is to serve people in society and protect people who are disadvantaged.
4. **Low authority, low responsibility**: Believes engineer's primary responsibility is to their client or employer and that engineers should abide by their directions without prioritizing a sense of obligation to government regulators, external organizations, or society.

The other two scales of the Professional Role Orientation Inventory also complement each other – Agency and Autonomy. These constructs are derived from psychology literature on "locus of control." Both constructs are related to one's sense of control over aspects of their professional life. **Agency** refers to one's control over one's own work and influence within the profession. **Autonomy** refers to one's freedom to act on their own judgments without needing to seek approval from others [20], [22]. Together these items assess whether someone is likely to act upon ethical decisions based on how they view their professional role. In addition to knowing what one ought to do, one must also feel they have to ability to act on that decision.

In summary, the four dimensions of the Professional Role Orientation Inventory assume that knowing how one views their professional role provides insights into moral values in their professional decision making. The instrument assumes that professionals conceive of their roles in different ways and that these conceptions lead them to emphasize differential moral considerations in their professional lives. The way that one conceptualizes their professional role can influence their response to an ethical situation [2].

IV. Methods

A. Course Context

With approval from the Institutional Review Board, we collected data to assess ethical motivation in an engineering ethics course offered in Spring 2022. Both authors were course instructors. Our course included fifteen upper-level engineering students from various disciplinary backgrounds, including multi-disciplinary engineering, mechanical engineering, nuclear engineering, and civil engineering. We received consent from students through a researcher not affiliated with the course. The course instructors (both authors) were not aware of who had consented to participate in the research study until the course concluded.

This study utilizes a convergent mixed-methods research design [23]. We collected quantitative and qualitative data concurrently throughout the course and will compare each set of data to understand how students' ethical motivation developed throughout the course. We will triangulate survey responses with student written reflection responses. This triangulation will enhance our confidence in survey results and provide contextualized examples of construct responses.

B. Quantitative Data Collection

We used a pre and post-course survey design to capture quantitative changes in students' ethical motivation. The survey includes three scales: (1) Valuing of Ethics, (2) Authority, and (3) Responsibility.

1) Valuing of Ethics Scale

We will study valuing of ethics by extending an instrument employed by Beever [24]. While in this work, Beever did not map items to constructs, here we purposefully group items to a tripartite theoretical operationalization of valuing of ethics comprised of ***personal value*** (i.e., how one perceives ethics as relevant to their own personal lives or careers), ***professional value*** (i.e., how one perceives ethics as important to one's STEM career), and ***interdisciplinary value*** (i.e., how one perceives different disciplines' perspectives as important for ethics). The valuing of ethics will serve as a proxy of what Tuana [5] describes as "moral purpose," a sub-component of moral motivation defined as "a state of commitment to a set of ethical values and goals." Specifically, this construct will reveal the extent to which students come into and leave the course valuing personal ethics, their professions' ethics, and the importance of integrating perspectives across disciplines.

2) Authority and Responsibility Scales

We adapted the Authority and Responsibility Scales of the Professional Role Orientation Inventory for an engineering context. The Professional Role Orientation Inventory was originally developed for dental students [20] and has been adapted to study physical therapists [19] and STEM researchers [25], though it has not yet been adapted to engineers. Because the Professional Role Orientation Inventory was originally developed for dentistry, some of the items are specific to dentists and are not applicable to engineers, such as items about patient interactions. These items were reworded or reconstructed and adapted to suit the engineering context. Most often, this involved replacing the word "dentist" with engineers. For example, the original Responsibility Scale included the item: "A dentist's obligation to serve humanity is no greater than the obligation of the ordinary person." We substituted "dentist" with "engineer" in our survey.

3) Administering the survey

We administered a pre and post survey in the Spring 2022 semester. The survey included 33 items and took approximately 15 minutes to complete.

C. Qualitative Data Collection

Throughout the semester, students drafted individual reflections to (1) ethical theories, (2) instructor-directed case studies (e.g., BP Deepwater Horizon spill; Tissued Engineered Heart Valves), and (3) self-chosen and self-directed case studies. Each reflection included personal lessons learned and students shared ongoing questions or challenges. In addition to these reflections, students drafted a Self-Reflection Paper that built upon their reflections. Our qualitative data analysis will use the set of survey constructs as a deductive coding framework to identify instances of each relevant construct.

D. Planned Data Analyses & Mixing Strategies

We will plot students' average responses to the Valuing of Ethics, Authority, and Responsibility Scales on the axes shown in Figure 1. Next, we will identify the number of qualitative codes of constructs and map this count to the axes.

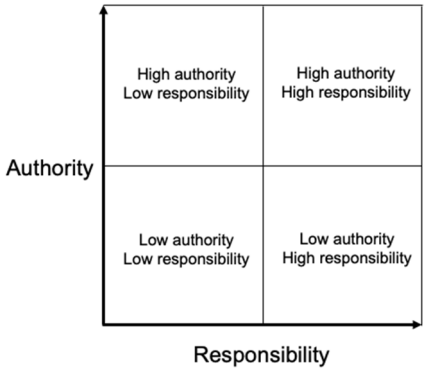

Figure 1. Visualizing the Authority and Responsibility dimensions of the Professional Role Orientation Inventory

This figure and the mapping of construct and qualitative coding incidents will help visualize where engineering students' role orientations converge, how these orientations may change over time, and how the other constructs vary across the quadrants. If students' scores tend to shift into a different quadrant over time, this result would suggest that students' experiences may have influenced their sense of professional authority and responsibility or their view of engineers' roles in society. We would hope to see students at the high end of the Responsibility spectrum. We are unsure how student responses on authority might shift, specifically due to the focus on prioritizing stakeholder perspectives in the course.

V. Conclusion

The goal of this study is to contribute to understanding ethical formation in engineering education. Prior research on ethical formation in engineering has largely focused on ethical judgment and ethical sensitivity. We expand on this work by exploring the role of ethical motivation in engineering students' ethical formation. Specifically, we aim to understand how students' valuing of ethics and professional role orientation could indicate the extent to which they internalize and prioritize the engineering profession's values. By assessing engineering students' ethical motivation, instructors can understand whether their engineering programs are preparing students to meet the goals of the profession. Findings from this study will provide insights into how a single engineering ethics course can influence the way students internalize professional engineering values and how this ethical formation may inform their future practice as engineers.

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