Assessing the self-efficacy level of Freshmen on Ethical Research and Practices in Engineering

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***Abstract*— Prior research shows that ethical misconduct occurs in all sectors of science and engineering, including laboratory-based research, engineering design, and data science and modeling. Problems have arisen at individual and across organizations. Many of the recent unethical incidents in scientific research involve data fabrication and falsification, data tampering, plagiarism, intellectual theft, and misinformation. A few examples of recently reported unethical behaviors in engineering in industry include the delayed response in the GM ignition switch failure case, the diesel emission software manipulation case at Volkswagen, and the lack of attention to user privacy by companies such as Facebook. These problems arise from numerous sources. One is insufficient ethical policies at the leadership level, as prior research has reported a positive correlation between companies' success and strong ethical policies at that level. Yet the idea that these problems can be solved solely at the leadership level seems flawed, as it is difficult to transfer ethical practices from the leadership to their team members if the latter have a weak or flawed understanding of what ethical responsibility entails, if without a proper ethical research efficacy assessment method and improvement plan.**

This paper presents preliminary findings from a National Science Foundation (NSF) funded project on ethical and responsible research (ER2) in science and engineering. More specifically, the NSF project aims to enhance ethical self-efficacy and competence in undergraduate engineering students through curricular interventions. While the overall goal of the NSF project also includes development of a validated scale to assess the ethical self-efficacy and competency of engineering students, the objective of this paper is limited to conduct a survey of first-year engineering students at Texas A&M University to establish baseline results for future work. Furthermore, based on the survey results, the paper also investigates differences in the ethical self-efficacy level of students based on their demographic attributes and high school education on ethics.

Keywords—self-efficacy, ethics, moral reasoning,

I. INTRODUCTION

Engineering has a direct relationship with society and can greatly impact societal relationships [1]. Ethical decision-making plays a crucial role in engineering and can have significant implications for human health and well-being [2]. Unfortunately, there have been numerous disasters that are, in part, attributed to lapses in ethical decision making. For instance, the Challenger Space Shuttle disaster in January 1986 is a clear example of how technical errors with ethical considerations can lead to catastrophic consequences [3]. Another tragedy was the collapse of the walkways at the Kansas City Hyatt-Regency Hotel in 1981, which resulted in one of the worst structural engineering mistakes in US history and claimed many lives [4].

Teaching institutions prioritize the training of engineers for their specific job roles in today's globalized world. Ethical conduct is a crucial aspect of engineering and scientific research, and its effectiveness is often measured in terms of moral awareness, ethical reasoning skills, an understanding of moral concepts, professional knowledge, and ethical self-efficacy. There are reasons to believe that unethical behavior, such as embezzlement of government research funds and data falsification, would be best addressed proactively using a systematic approach to ethics education [5]. This aim has been supported by ABET, the accrediting body for engineering and technology related degree programs, which has included its importance in its list of student outcomes since at least 2003 [6].

In order to address the crucial need for Engineering Ethics Education, both educational institutions and companies have adopted various approaches. Two common methods for incorporating ethics education into the engineering curriculum include standalone engineering ethics courses taught in a traditional classroom setting [7], and a hybrid approach combining practical training along with lectures that presents students with real-world case studies and scenarios [8]. For

instance, instructors may utilize case studies such as the Chornobyl nuclear disaster [9] or the BP Deepwater Horizon oil spill [10] to help students understand the significance of safety and environmental sustainability in engineering practice. Similarly, some scholars have emphasized the importance of integrating cultural and social responsibility, as well as professional ethics and responsibility, into the engineering curriculum to foster moral awareness and prepare students for ethical challenges they may encounter in their professional careers [11].

With the implementation of ethics education, the assessment also plays a crucial role to measure the level of ethical self-efficacy, moral reasoning, and professional readiness of students. According to research, pre- and post-course surveys are the most commonly used method of assessment [12]. Additionally, assessment tools like the Engineering Professional Responsibility Assessment (EPRA) [13] and the Engineering and Science Issues Test (inspired by the Defining Issues Test, the DIT-2) [14] have been created to measure different aspects of ethical competency in undergraduate engineering students. Researchers have also included qualitative assessments alongside their findings to gain a better understanding of how universities are incorporating ethics and civic education into their curricula. They evaluate open-ended exam questions, research papers, essays, interviews, self-reflective essays, etc. These responses are transcribed and ethical dilemmas are derived to analyze the data [15], [16].

This study is part of a large ongoing research project aimed to improve ethical self-efficacy and competence in future STEM researchers through curricular intervention, funded by NSF's Ethical and Responsible Research program. To that end, the main objective of the NSF project is to better understand, assess and improve the ethical formation of engineering students by measuring how their ethical awareness, knowledge, reasoning skills, and self-efficacy are formed by their high school education and impacted by their experiences at the university. One element of the project is to develop and administer a baseline measure of a student's moral competence, ethical self-efficacy, and ethical competency. As a part of the overall project, new educational modules will be developed for undergraduate engineering students. The baseline measure will inform the design and content of the new modules. A second aim is to provide programming for high school instructors, who will develop lesson plans to add an ethical dimension to their courses. The objective of this paper is to present results and analyses of a baseline survey of ethical self-efficacy and competency of first-year and senior-year engineering students. It will also investigate the relationship between high school educational experiences and demographic attributes on engineering students' moral beliefs and competencies is presented.

II. RESEARCH DESIGN

As stated earlier, this study represents a part of a comprehensive research design investigating the ethical self-efficacy and competency level of engineering students. The survey included 20 questions covering four constructs assessing the personal values and moral judgment capacity level of the students. The four constructs included motivation, honesty, collaboration, and career-life alignment. Each construct has four to five questions that provide an indirect measure of a student's moral compass. In addition, the survey comprised demographic attributes and students' high school experiences. This paper aims to answer following research questions.

RQ1. How well are students prepared to deal with decisions that involve moral judgments measured through four constructs (motivation, honesty, collaboration, career life alignment), hereafter referred to as their moral compass?

RQ2. Is there any significant difference in the mean scores of the four constructs based on student demographic variables and high school experiences?

RQ3. How do these scores for seniors compare to those for first year students?

A. Survey Instrument

The survey consists of a multilevel and multi-section questionnaire testing ethical self-efficacy, moral reasoning, and awareness of ethics among students in their first-year and senior-year in engineering. The present study aims to measure the level of ethical self-efficacy among students in terms of four major constructs: motivation, honesty, collaboration, and career-life alignment. The survey questions also included students' demographic attributes and high school experience. Lastly, a few attention-check questions were included in the survey to maximize the data integrity.

B. Data Collection

Of the 4000 students surveyed, 75% of them were first-year students and the remaining 25% were seniors who were currently taking a course in engineering ethics. Data collected from two different groups (first year and senior students) allows the researchers to understand the extent to which students have gained self-efficacy related to ethical research and practice undergoing their engineering education while attending the university in comparison to entry-level students. Before electronically launching the survey, appropriate IRB approvals were received. Out of 4000 students, 1400 students responded. About 150 responses were removed from the data set due to either incompleteness or unreliable responses, thereby leaving 1250 responses for further analysis (or 28% response rate). We believe 28% response rate is an adequately representative sample for further analysis. Out of the 1250 responses, 650 were first year students and the remaining 600 were seniors.

C. Demographic Characteristics

The demographic attributes of all the students (first year students and seniors) are depicted in Table 1.

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TABLE I. DEMOGRAPHIC ATTRIBUTES OF STUDENTS RESPONDING

Hispanic, Latino or Spanish Origin		Gender	
Yes	24%	Male	78%
No	73%	Female	22%
Do not wish to specify	2%	Other/No response	2%
Which of the following best describes you?			
White	75%	Hawaiian	0.2%
Asian	16%	Do not wish to specify	6%
Black or African American	3%		

Out of total population distribution (first year students and seniors), about 21% of all the respondents were female. About 75% of them were White, 15.5% Asian, 3% Black or African American, and about 6% of students chose others or did not wish to specify race. 24% of the respondents said they were Hispanic or Latino, whereas 74% of students said they were not, and 2.5% did not wish to specify. In that context, the survey response is representative of the student population as the gender and ethnicity split represents the overall population distribution at the university.

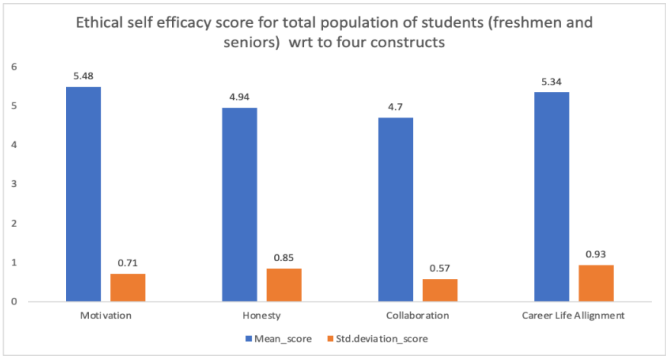
D. Data Analysis and Discussion

The following sections describe the survey findings with respect to the three research questions stated earlier. Analysis of student's ethical self-efficacy as reflected by their moral compass is used to address RQ1. The objective of this analysis is to measure the ethical attitudes and moral values, and beliefs for students based on their high school experience for first year students and exposure to ethics courses in the university for senior-year students. To determine the students' moral compass, they were provided with questions related to four major constructs motivation, honesty, collaboration, and career life alignment in the survey, and the answers were recorded on a scale of 1-7. The mean and standard deviation of self-efficacy scores for each construct were calculated for the entire respondent population and represented in the form of a bar graph given in Fig.1. As seen from the graph, the mean score for all the constructs vary between 4.5-5.5 which indicates a good level of understanding and acknowledgment of ethical awareness among the students.

Fig. 1. Mean self-efficacy scores along with standard deviations.

An analysis of students' moral compass based on demographic attributes and high school experience is used to assess RQ2. All the students were asked the same demographic and high school education questions. Based on the responses in the demographics section, the ethical self-efficacy measured through their attitudes, moral values, and beliefs scores were grouped and then the mean and variance for each group were calculated and compared by conducting a series of t-tests. Based on the p values from the t-test the results were analyzed and presented in Table 2.

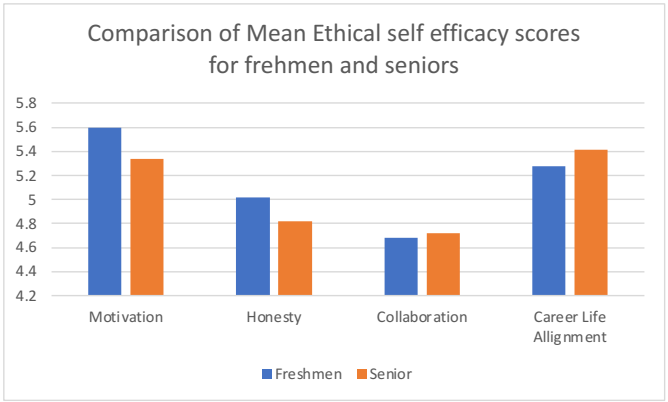
Table 2 illustrates how demographic characteristics affected



the scores among the four constructs divided to measure the moral compass of students. Ethnicity and multiple AP courses in high school had no significant effect on ethical self-efficacy scores. On the other hand, we discovered that female students scored higher than male students on questions about honesty. Students of Hispanic and Latino ethnicity scored significantly better on motivation-related questions than others. Students who answered "Yes" to the question "Do you or anyone in your close family has a disability of any kind?", outperformed other students on questions falling in the collaboration construct.

After analyzing the responses of the complete survey, the mean ethical self-efficacy scores for seniors and first year students are compared to see how the score vary among four constructs; this analysis address RQ3. From Fig. 2 it can be observed that first year students scored higher in questions related to motivation and honesty. Seniors scored higher on questions related to collaboration and career life alignment. One possible explanation for the difference in results is that seniors have learned through the challenges they face in ethical decision-making and moral awareness from their academic experiences at the university going through different course work, assignments, and research activities whereas first year students have just joined the college and rely heavily on the education they have received in their high school.

Fig. 2. First year students vs. seniors: student self-efficacy scores.



III. CONCLUSIONS AND FUTURE WORK

This study aimed to evaluate the moral compass of engineering students based on their high school experience and demographic characteristics. This research study is part of a project which is still a work in progress. In this paper, the authors compared the responses of first year students and seniors from

the same university to measure the students' ethical decision-making skills and moral awareness. The mean scores for ethical self-efficacy based on four major constructs: motivation, honesty, collaboration, and career-life alignment were calculated based on students' responses. The results showed that seniors scored higher in all the constructs than first year students, indicating that their exposure to ethics courses, decision-making challenges, and the university environment had a positive impact on their moral compass. Moreover, the self-efficacy scores varied based on students' gender, ethnicity, and family disability status. Overall, engineering students demonstrated a good level of moral awareness and ethical decision-making skills.

In terms of future work, this initial study can be expanded to conduct longitudinal research on various engineering courses offered by the university. The study will involve students from different academic standings (e.g., sophomore, junior, and senior) to examine how their ethical self-efficacy evolves with their educational experience. The survey tool can be improved to incorporate feedback from students on the ethics courses they are exposed to in their engineering curriculum.

TABLE II. T-TEST RESULTS FOR MEAN SCORES AMONG FOUR CONSTRUCTS

Construct	Gender (Male/Female)	Ethnicity Hispanic/Non-Hispanic	Race (White/Asian/Black or African American/Hawaiian)	Multiple AP Courses (Yes/No)	Disability Status (Yes/No)
Motivation	Fail to reject H0	Yes>No	Fail to reject H0	Fail to reject H0	Yes>No
Honesty	Female>Male	Fail to reject H0	Fail to reject H0	Fail to reject H0	Fail to reject H0
Collaboration	Fail to reject H0	Fail to reject H0	Fail to reject H0	Fail to reject H0	Fail to reject H0
Career-Life Alignment	Fail to reject H0	Fail to reject H0	Fail to reject H0	Fail to reject H0	Fail to reject H0

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