Engineering Education in Human Rights and Sustainability: Exploring Students' Motivations and the Learning Outcomes from an Undergraduate Class at the University of Connecticut

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Abstract: How does a Human Rights framework in engineering curriculum affect undergraduate students' attitudes and opinions of sustainability and human rights? Deepening inequality worldwide, aggravated by climate injustices and the effects of the COVID-19 pandemic, has increased engineering scholars' awareness of the necessity of developing a new engineering pedagogy and corresponding ethical framework to prepare an engineering workforce that can perform successfully and efficiently in multicultural and globalized settings. The University of Connecticut (UConn) has pioneered in developing a curriculum that equips engineering students with core concepts and methodological tools necessary to analyze the role of engineering in society, using a Human Rights framework. This paper explores learning outcomes in an existing course within this curriculum (i.e., "Engineering for Human Rights") by analyzing original exit survey data from enrolled students. Our survey instrument integrated New Ecological Paradigm (NEP) statements to assess variation in perceptions of the usefulness of the course content as it relates to sustainability. The findings of this study have implications and suggestions for designing interdisciplinary curricula that integrate engineering, sustainability, and human rights in engineering education.

Keywords – Human Rights framework, engineering pedagogy, sustainability, New Ecological Paradigm (NEP), engineering for human rights

INTRODUCTION

Sustainability means meeting the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development, 1987). The United Nations Educational, Scientific and Cultural Organization (UNESCO), in its report "Engineering for Sustainable Development: Delivering on the Sustainable Development Goals (SDGs)," states that engineering is essential to ensure equal opportunities and sustainable development for all. Furthermore, the report highlights the crucial role that engineers play in shoring up the resilience of particularly vulnerable groups facing severe crises (UNESCO, 2021).

The urgency of the climate crisis and deepening inequality around the world require the development of an engineering workforce that can perform successfully in multicultural and globalized settings. In this context, several scholars, international organizations, and educational institutions have sought to stimulate engineering students' interest in thinking critically about traditional engineering approaches and interpreting engineers' ethical obligations in terms of environmental sustainability and fundamental human rights such as the right to safety, health, and wellbeing of the public (Lucena and Schneider, 2008, pp.251-252). The voluntary organization Engineers Without Borders (USA), for example, promotes ethical and sustainable engineering solutions that protect human dignity and respect for the environment. Similarly, the American Society for Engineering Education (ASEE) urges that "Engineering students should learn about sustainable development and sustainability in the general education component of the curriculum as they are preparing for the major design experience. (ASEE, n.d., p. 1.)"

Sustainability hinges in part on the ability of faculty to understand and shape students' attitudes and behaviors towards sustainability (Misseyanni et al., 2020, p. 173). The University of Connecticut (UConn) has pioneered in developing a curriculum that equips engineering students with fundamental knowledge about human rights and with the skills to assess the impact of engineering on society.[1] This curriculum includes a specialized engineering track within a university-wide undergraduate Human Rights Major/Minor as well as a specialized track within a Multidisciplinary Engineering Degree.

In order to evaluate the influence that such a human rights-based approach to engineering education has on students' opinions and attitudes, this article explores the preliminary results of a survey conducted among students who enrolled in the University of Connecticut's "Engineering for Human Rights" course in Fall 2021 and Spring 2023. We discuss the implications of human rights for engineering and vice versa, within the context of new engineering pedagogy focused on Human Rights. We then explain the methodology employed for our survey and introduce our preliminary results. The paper concludes with lessons learned, derived from our survey responses and course evaluations, and future plans.

[1] The University of Connecticut's broader Engineering for Human Rights Initiative (EHRI) is "a collaborative venture between UConn's College of Engineering and the Gladstein Family Human Rights Institute that addresses human rights implications of the most significant challenges in engineering and technology." See https://engineeringforhumanrights.initiative.UConn.edu/

HUMAN RIGHTS IN ENGINEERING EDUCATION

Human rights refer to a claim by someone, on someone, for something essential to human dignity (Gewirth, 1992). Human rights are inherent to all human beings, whatever their nationality, place of residence, sex, national or ethnic origin, color, religion, language, or any other status. According to the Office of the United Nations High Commissioner for Human Rights (OHCHR), training and education in human rights is essential to prevent human rights abuses and constitutes a key investment for a just society. In this context, scholars have tried to develop engineering curriculum based on the Human Rights-based approach because they believe that education is integral to deepening students' perceptions and increasing their willingness to advocate for human rights.[2]

Some scholarly work has focused on key elements missing from traditional engineering education in relation to human rights. Specifically, Leydens & Lucena (2017) argue that social justice is often invisible within conventional engineering education and practice. There are several "generic barriers to rendering social justice visible" (Leydens & Lucena, 2017, p. 46). First, certain cultural norms and their values dominate the cultural discourse of normalcy in engineering and deviations from the norms are often marked. Second, the values of the dominant groups are considered superior. Third, unconscious biases are commonplace in STEM workplaces Fourth, people must recognize "cultural privilege or oppression emanated from cultural normalcy and superiority" (Leydens & Lucena, 2017, 48).

These authors also mention some engineering-specific barriers to making social justice visible. Within the United States, for example, three engineering ideologies bolster and sustain engineering culture: technical-social dualism, depoliticization, and meritocracy. Technical-social dualism separates the technical from the social in engineering although engineering problem solving (EPS) always occurs in social contexts. This ideology is prevalent in engineering sciences and courses. Depoliticization is an approach that considers "technological artifacts as neutral, asocial, and apolitical" (Leydens & Lucena, 2017, p. 52). "Both sociotechnical dualism and depoliticization serve to render social justice dimensions invisible or irrelevant" (Leydens & Lucena, 2017, p. 55). Meritocracy conveys the false conception that a merit-based system is working well based on the belief that success in a person's life is the consequence of their characteristics such as talent, training, and motivation. This ideology often justifies the ignorance of multiple factors including gender, race, ethnicity, disability, and socio-economic class, all of which can influence a person's chances of success (Leydens & Lucena, 2017, p. 56).

Building upon the work of Donna Riley (2008), Leydens & Lucena (2017) discuss additional mindsets in engineering that stymie engagement with the field's social justice dimensions. First, the centrality of the military and corporations as workplaces and the rules, norms and practices of these organizations together shape engineers' behaviors and ways of thinking. Next, an uncritical acceptance of authority is problematic. Third, engineering education and workplaces typically lack approaches for enabling engineers to develop a deeper sense of the social, emotional, or basic physical elements of the machines and processes they

[2] The Human Rights-based Approach is a conceptual framework for the process of human development that is normatively based on international human rights standards and operationally directed to promoting and protecting human rights.

engage with daily. Instead,

> "Engineers develop a narrow sense of the technical as something that can be imagined and solved on paper (or on screen) without a sense for what it takes to build something (e.g., amount of physical exertion, availability of raw materials, tools, permits) and for its consequences on social justice (e.g., labor conditions required, risks/ harms imposed on users and/or the environment)" (Leydens & Lucena, 2017, p. 59).

Fourth, an overreliance on the scientific methods is problematic in engineering education because it is not an *exclusive* inquiry method designed for research questions (Leydens & Lucena, 2017, p. 60). In other words, there has been the myth of objectivity in traditional engineering education, which presumes engineering and scientific research design is purely objective and true (ibid). Leydens & Lucena (2017) highlight that engineering scholars and students began moving beyond these four obstacles by building upon a growing societal desire to use their capabilities to help humanity in the early 1990s (pp. 60-61). This idea centrally relates to our pedagogical innovation in grounding engineering education in a human-rights based approach.

Our work in this paper builds on a growing conversation in the field regarding the varied influences on engineering students' perceptions and the evolution of professional engineers' careers. Some work explores the potential influence of a Human Rights-based approach to engineering education on diversity in gender, ethnicity, and culture within the field. For example, diverse scholars have found that a high retention rate of women (or female students) is closely related to this new approach to education (Villa and Gonzalez, 2011; Bielefeldt, 2014; Groppi & Tappero, 2015; Shankar et al., 2017; Jayakumar & Nozaki, 2020; Suran, 2021).[3] Other researchers have focused on the influence of a new type of engineering curriculum on undergraduate students' perceptions of or attitudes toward sustainability and human rights. Kuo & Jackson's survey results (2014) reveal a close association between environmental studies courses and students' propensity to adopt more pro-environmental attitudes and related beliefs about ecological crisis, the practical constraints of resources, and the vulnerability of nature's balance.

DEVELOPING NEW ENGINEERING PEDAGOGY

A wide range of scholarly work explores specific forms of pedagogical innovation that we argue could be used to mainstream human rights within engineering education. One strand focuses on changing the terms of course goals and the approaches to targeting students (Wilcox & Akera, 2014), learning methods (Hoole & Hoole, 2002; Shankar et al., 2017), assignments (Bielefeldt, 2014) and interdisciplinary approaches (Brower et al., 2007; Leydens and Lucena, 2016). Wilcox and Akera (2014) focus on the positive effect that Rensselaer Polytechnic Institute (RPI)'s first-year Sustainability Studies course "Nature/Society" has had on increasing

[3] Several scholars also found the positive influence of a Human Rights-based approach in primary education. For example, some authors argue that learning the importance of Human Rights and empowering children through education can increase their support for human rights, tolerance, and multiculturalism (Decoene and De Cock, 1996). Similar results were found by Covell and Howe (1999) in Nova Scotia.

student knowledge of sustainability and promoting student engagement across diverse demographic groups. This course "is designed to foster critical thinking about human/environment interactions through humanistic and social scientific inquiry (Wilcox & Akera, 2014, p. 3)." Hoole and Hoole (2002) argue that careful consideration of diverse composition among students, along with teachers' own perspectives on human rights and a commitment to a horizontal class culture have together undergirded the new engineering curriculum at the University of Peradeniya; these elements enable professors and engineers alike to understand the importance of human rights, fairness, and justice in society. Similarly, Shankar et al. (2017) have argued that interdisciplinary courses involving both engineering and social science students and grounded in case study pedagogy can play a crucial role in promoting students' team-building skills, social awareness, and the metacognitive processes. Bielefeldt (2014) emphasizes that female students' reflective essays have significantly impacted students' own perception of engineering and the profession's role within society.

A second strand of scholarly work emphasizes the role of experiential learning through summer programs (Groppi & Tappero, 2015), student exchange programs (Fox et al., 2018), mentored grant-funded research projects (Espiritu et al., 2021; Perez & Plumlee, 2022), and internships (National Academies, 2017). Groppi and Tappero (2015) analyze a team-based summer program on renewable energy (culminating in service-based learning projects) which they find serves to increase the retention rate of students from underrepresented minority groups as well as first-generation and female students. Similarly, Fox et al. (2018) find that a one-week study abroad course jointly offered by Indiana University and Purdue University Indianapolis (IUPUI) increased students' support for sustainable development. Perez and Plumlee (2022) similarly found that at Boise State University (BSU), student interest in sustainability increased among mechanical engineering students who took a course which emphasized sustainability more than among students who did not take the course. Notably, female students were more impacted than male students among those who experienced increased interest. The National Academies of Sciences (NAS) has also reported that undergraduate research experiences including internships offer students the opportunity to alter their perceptions of climate change (NAS, 2017).

ENGINEERING FOR HUMAN RIGHTS

The College of Engineering at the University of Connecticut launched a new major in Multidisciplinary Engineering (MDE) and has developed corresponding human rights and sustainability required courses, including "ENGR/HRTS 2300: Engineering for Human Rights." This 3-credit seminar enrolls undergraduate students interested in the broader social implications of engineering and technology. The faculty who designed and teach this course define engineering for human rights as "a paradigm that draws on a universal set of principles to shape individual ethical obligations and the norms of the profession to mitigate risk, enhance access to the benefits of technology, and redress harms resulting from engineered products or processes" (Chacon-Hurtado et al., 2023, p. 2).

Engineering for Human Rights explores the role of engineering in society, drawing on a range of ethical paradigms and human rights principles. Designed to include engineering and non-engineering undergraduate students in a dynamic, case-study-based learning setting, the

seminar equips students to assess engineering practices in relation to the engineering ethical paramount of protecting public welfare. This seminar includes four modules covering:

1. Foundational concepts of human rights and related ethical paradigms (including concepts of sustainability and social justice),
2. Historical perspectives on the role of engineers as "problem-solvers" and related impact on the social and cultural dimensions of communities,
3. Human-rights-based approaches to engineering practice with principles of distributive justice, participation, consideration of duty bearers, accountability, indivisibility of rights,
4. The application of concepts through case-based learning, including both domestic and international case studies (e.g., Wind energy in Brazil or Niagara Falls power plant in the US)

In addition to weekly reading, short essays, and mid-term and final exams, students are assigned to small groups and together develop a written evaluation of the human rights impact of one engineering project. Each group can autonomously decide its project topic and targeted case study, and various practical cases used for lectures and in-class discussions are closely related to the project groups' intensive group case study. The faculty who teaches Engineering for Human Rights carefully create student teams by considering their diverse demographic characteristics (such as gender, school year, or first-generation college student status) and with a view toward ensuring diversity of majors within each group. Furthermore, a series of guest lectures in this course allow students to discuss the challenges of implementing related practices in the field through dialogue with invited speakers from companies and/or nongovernmental organizations. At the end of the semester, the seminar culminates in a symposium (poster session), featuring the group-based assessment results.[4]

METHODOLOGY

This paper explores learning outcomes in an existing course within this curriculum (i.e., "Engineering for Human Rights") by analyzing original exit survey data from enrolled students. We used the revised New Ecological Paradigm (NEP) scale to measure variation in the environmental concerns, attitudes of students enrolled in the course, and their perception of the usefulness of the course content on sustainability in the context of engineering. The revised NEP scale aims to measure attitudes towards the environment and was developed as described in Dunlap et al. (2000). The NEP aims to grasp the respondents' foundational beliefs about the human-environment relationship and their environmental concerns (Stern & Guagnano, 1995). This widely accepted paradigm consists of 15 statements in which respondents rank their agreement key items using a 5-point Likert scale. Dunlap et al. (2000: 432) categorize these statements into 5 groups: the reality of limits to growth (1, 6, 11), anti-anthropocentrism (2, 7, 12), the fragility of nature's balance (3, 8, 13), rejection of exemptionalism (4, 9, 14) and the possibility of an ecological crisis (5, 10, 15). The Likert scale used to rank each item is based on a 5-point scale and the option of 'Don't Know': Strongly

[4] Additional details about the class can be found in Chacon-Hurtado et al. (2022).

Disagree, Disagree, Neither Agree nor Disagree, Agree, Strongly Agree, and Don't Know. Figure 1 shows 15 NEP statements used in our survey. Each statement asks students about their opinion of the human-environment relationship or environmental concerns, including ecological crisis. Even though Dunlap (2008) highlights that the NEP scale has a potential to become a universal measure, Dyr & Prusik (2020) point out that the NEP scale cannot be free from context-specific situations or cultural relativism. In this context, this study admits that similar responses of different students may originate from different understandings of what NEP asked. Nevertheless, considering diverse gender, ethnic, and educational (major/specialty) backgrounds of students taking the course, we argue that our original exit survey data using the revised NEP scale can provide limited but meaningful implications on the students' attitudes toward the environment.

NEP Statements

1. We are approaching the limit number of people the Earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will ensure that we do not make the Ear unlivable.
5. Humans are seriously abusing the environment.
6. The Earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities humans are still subject to the laws of nature.
10. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
11. The earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course, we will soon experience a major ecological catastrophe.

Figure 1. 15 NEP Statements in Survey (Retrieved from Dunlap et al. (2000), p. 433)

In addition, students were asked to indicate their opinion in three human rights statements in order to gauge attitudes toward human rights: *the right not to be tortured*, *the right to freedom of thought and expression*, and the *right to a minimum guaranteed standard of living*. The first statement is grounded in the notion of human rights as one's freedom from physical and mental torture. This perspective considers human rights to be a legitimate claim that demands the absence of threat or attack both physically and psychologically. The second statement defines human rights as the prerequisite for people to survive. The third statement emphasizes that human rights are secured when people's ideas, opinions, and information are not interfered with or threatened by anyone or any condition.

Figure 2 shows the human rights statements we used in the survey. These human rights statements are grounded in the articles of three foundational pieces of international human rights law, namely: the Universal Declaration of Human Rights; the Convention against Torture and Other Cruel, Inhuman or Degrading Treatment or Punishment (CAT); and the International Covenant on Civil and Political Rights (ICCPR), see Hertel et al. (2009). These three human rights statements have the advantage of covering a range of human rights, i.e., not only civil and political rights but also basic economic rights.

1. Freedom from physical and mental torture.
2. A guaranteed minimum standard of living.
3. Freedom of thought and expression

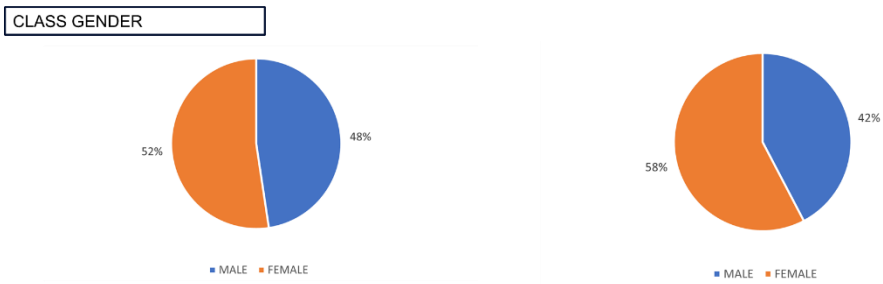
Figure 2. Three Human Rights Statements in Survey (inspired by Hertel et al., 2009, p. 444)

The human rights instrument integral to our survey uses Belief Parameters, which consist of indicators that assess how actively respondents agree with the unconditional guarantee of human rights. We used three different types of parameters: Unconditional/Absolute ("It is a right that should be guaranteed to every human and never violated"); Conditional (It is a right that may be desirable but that can be violated under certain circumstances"); and Disagreed/Denied ("It is not really a right at all"). These parameters are listed below.

1. It is a right that should be guaranteed to every human and never violated.
2. It is a right that may be desirable but that can be violated under certain circumstances.
3. It is not really a right at all.

CONTEXT OF THE STUDY

We surveyed students enrolled in two different semesters in our Engineering for Human Rights course, i.e., in Fall 2021 and Spring 2023. The demographics of the two class sections are shown below. On the left-hand side is the class of Fall '21 and on the right-hand side is the class of Spring '23. Students enrolled from different units across the University of Connecticut; gender, enrollment unit, and the year of study of each student were recorded.



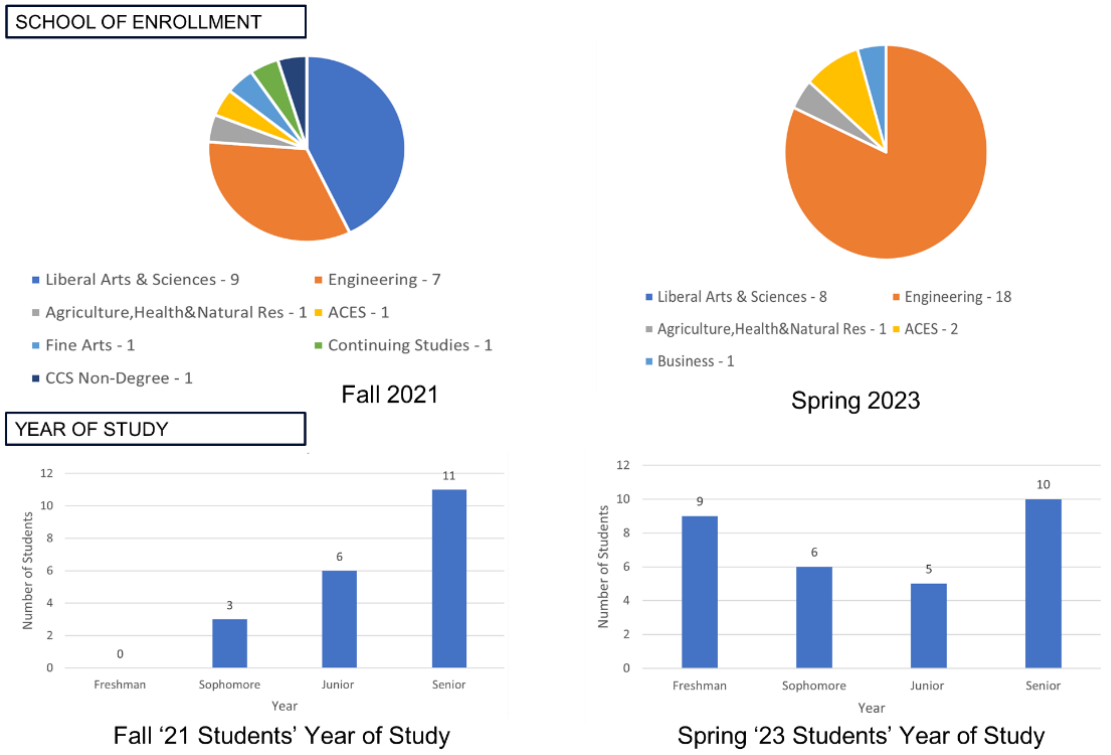


Figure 3. The Demographics of the Students enrolled "Engineering for Human Rights" in the Fall of 2021 and the Spring of 2023 (Source: Authors)

14 students out of 47 invitations participated in our survey and the number of students surveyed corresponds to 30% of the enrolled students.

PRELIMINARY RESULTS

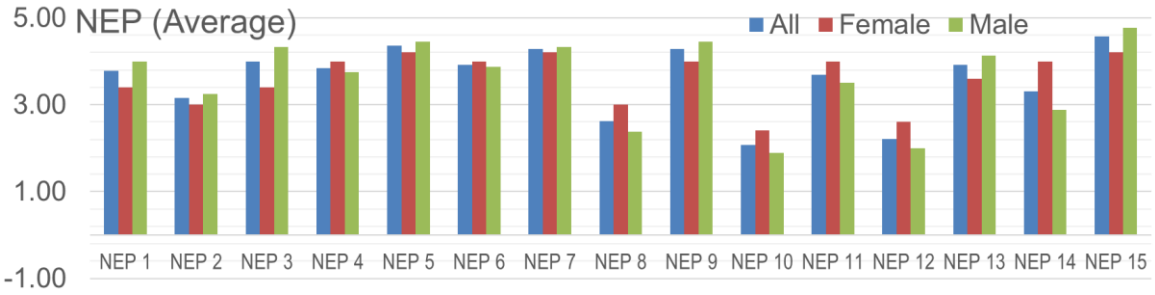


Figure 4. The Average Scores of the Students' Responses to 15 NEP Statements (Source: Authors)

Despite a relatively small number of responses, our three major findings central to this study have implications for the design of interdisciplinary curricula that integrate engineering,

sustainability, and human rights within engineering education. First, according to Figure 4 which describes our NEP survey results, respondents are likely to oppose a human-centric approach to ecological issues overall, especially in the NEP statements 8 ("The balance of nature is strong enough to cope with the impacts of modern industrial nations."), 10 ("The so-called 'ecological crisis' facing humankind has been greatly exaggerated."), and 12 ("Humans were meant to rule over the rest of nature."). In other words, the students who enrolled in the "Engineering for Human Rights" course show strong support for the pro-ecological approach to environmental issues generally. In addition, female students tend to answer that they enrolled in this course because they are interested in exploring the potential role of human rights in engineering, or they want to learn about sustainability.

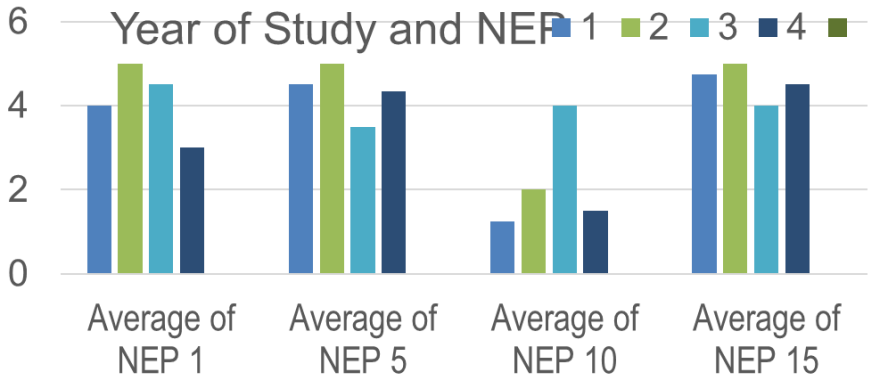


Figure 5. The Average Scores of the Students' Responses to NEP Statements 1, 5, 10, 15 by the Year of Study (Source: Authors)

Second, although a few juniors respond that the current ecological crisis has been exaggerated, the majority of respondents agree on the necessity and urgency of solving environmental issues for the sustainable future of human beings regardless of the year of study. For example, according to the survey result shown in Figure 5, the average NEP score of junior students to Question 10 "the so–called ''ecological crisis'' facing humankind has been greatly exaggerated" is 4 and the average of other students is 2 or below. Similarly, regarding Question 5 "humans are seriously abusing the environment," Junior students show the lowest support for this argument compared to the other students. Nevertheless, Junior students strongly agree the claim on Question 1, "we are approaching the limit number of people the Earth can support." These findings imply that students generally agree that environmental issues have become salient and eminent even though some of them deny the primary responsibility of humans on that issue. In other words, based on Dunlap et al's (2000) grouping of the 15 NEP statements, the perceptions of Junior students in our surveys reveal relatively low support for the possibility of an eco-crisis, but they tend to agree with the existence of the reality of limits to growth, like other students.

Third, given the results of our human rights questions in Figure 6, no student denies that certain examples of human rights such as freedom from physical and mental torture, a

guaranteed minimum standard of living, and freedom of thought and expression are human rights. In addition, students are likely to strongly support unconditional or absolute protection of human rights – including both physical protection and intangible rights such as freedom of thought and expression. Overall, these three findings reveal that the students who responded to our survey strongly support human rights-based approaches to environmental and social issues. Our results contradict the conventional wisdom that people in the United States do not support social and economic rights; indeed, most students we surveyed support a minimum standard of living.

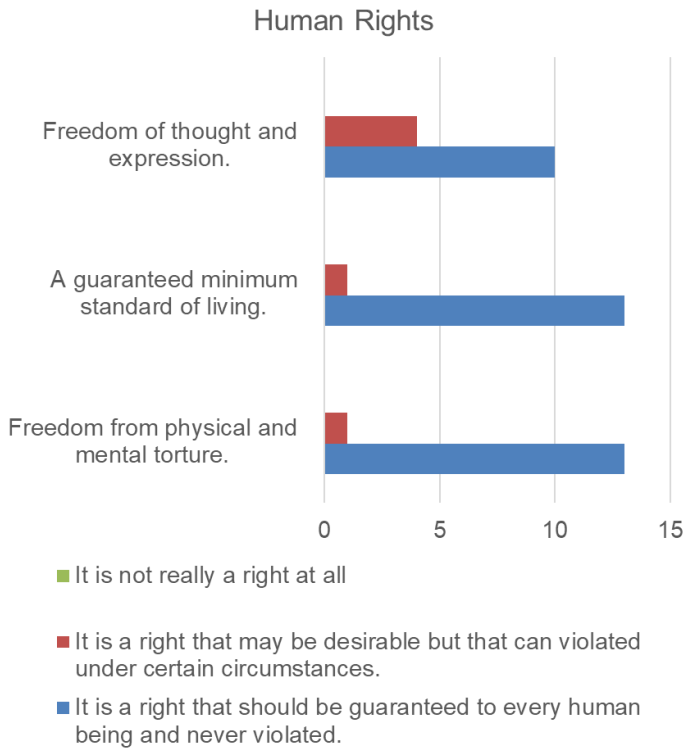


Figure 6. Students Responses to Three Human Rights Statements (Source: Authors)

CONCLUSIONS AND FUTURE WORK

This paper investigates the attitudes of students who have experienced a human rights-based approach to engineering pioneered at the University of Connecticut. The pedagogical aim of our approach is to equip engineering students with core concepts and methodological tools necessary to analyze the role of engineering in society, using a Human Rights framework. Our research findings reveal that designing interdisciplinary curricula which integrate engineering, sustainability, and human rights within engineering education can indeed increase students' support for sustainable development and human rights regardless of the differences in gender and year of study between them. This work has an important implication that engineering classes that broaden their technical discussions to include topics related to human

rights and the environmental impacts of engineering could help raise students' interest in sustainability and equity. This interest may be translated into a willingness to act and impact their everyday work as future engineers.

Further work will aim to increase the sample size for this analysis. This implies collecting data from students who have taken this class in recent semesters and assessing whether the trends found in this initial analysis stay the same. Similarly, the survey will be run by students not enrolled in the "Engineering for Human Rights" class to see whether there are significant differences between groups.

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