Exploring Learning Outcomes in Human Rights-Focused Engineering Classes using Mixed-Method Text Analysis

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[WIP] Exploring Learning Outcomes in Human Rights-Focused Engineering Classes using Mixed-Method Text Analysis

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Abstract – Recent efforts to incorporate a human rights-based approach into engineering curricula aim at expanding professional engineering ethics to include the core values underpinning human dignity. This study assesses the learning outcomes of undergraduate engineering courses that emphasize accountability, indivisibility of rights, distributive justice, equal participation, and consideration of duty bearers. We employ natural language processing (NLP) techniques to answer two research questions about human rights (HR) education in engineering: (1) What lexical patterns characterize students' discussion posts across the semester, and (2) how does students' engagement with human rights vocabulary evolve from the first to the second half of the course? Based on the 116 collected discussion posts from 12 student volunteers across Spring and Fall 2025, this paper applies four complementary NLP approaches: an HR lexicon density analysis tracking vocabulary adoption across a deductively constructed 56-term, five-category framework; a reading-controlled vocabulary analysis separating passive reading-echo from active conceptual transfer and novel HR application; TF-IDF cosine similarity to a core HR reference corpus; and lexical sophistication measures including diversity, breadth, and specificity. Preliminary findings indicate that human rights-focused engineering courses can foster meaningful internalization of the HR framework, as evidenced by a convergent increase across methods in vocabulary frequency, conceptual breadth, and lexical sophistication, driven primarily by conceptual transfer and novel application rather than passive reading-echo.

Keywords – human rights, engineering education, learning outcomes assessment, engineering ethics, Natural Language Processing (NLP), lexical development

Introduction

Engineering has the potential for extensive and enduring impact on human and environmental systems. Indeed, engineering design does not take place in a vacuum, but rather within socio-technical and political systems (Leydens & Lucena, 2014; NAE, 2017). Yet engineering education research has shown that learning related to public welfare and ethics among undergraduate engineering students declines with seniority (i.e., from first-year to senior-year students; Cech, 2014). Despite professional recognition of the primacy of ethics for the field (NAE, 2004, 2005), students still struggle to see connections between their work and societal issues related to public welfare. Furthermore, issues affecting public welfare, such as social exclusion, poverty, and hunger, are not addressed in traditional engineering education.[1] This article assesses the impact of efforts to provide engineering students with human rights-based pedagogical frameworks that translate ethics into actionable steps linked to standards for accountability across engineering fields and within design processes.

We frame the critical role of engineering in society in relation to human rights principles. Based on Chacon-Hurtado et al. (2024), we argue that a human rights framework provides an encompassing language grounded in universal principles of interrelatedness, indivisibility, and equity. We analyze learning outcomes of students enrolled in a class in which human rights-based lectures and case studies should ideally equip engineering students to address both existing challenges and the potentially disruptive impacts of emerging technologies, as human rights are grounded in minimum standards that uphold human dignity. This paper i) shares the pedagogical methods and content of the "Engineering for Human Rights" course and ii) analyzes students' learning trajectories using a mixed-method approach combining four NLP techniques with qualitative close reading of student discussion posts.

This study has two research questions, explored through analysis of 116 discussion posts from 12 student volunteers during two semesters of the class (Spring 2025 and Fall 2025): First, what lexical patterns and thematic trends characterize students' written reflections in the "Engineering for Human Rights" course across the semester? Second, how does students' engagement with human rights-related vocabulary shift between the first half (Weeks 1-6) and the second half (Weeks 7-12) of the course?

These questions situate our NLP analysis within the broader goal of understanding how students apply a human rights-based framework in their ethical reasoning. We also aim to strengthen methodological transparency and deepen our understanding by combining qualitative analysis in this study.

Background Concepts

Human Rights

The United Nations *Universal Declaration of Human Rights* (UDHR) has served as a globally recognized standard that briefly outlines the essential rights, including life and liberty, the right to work and education, among other civil, political, economic, social, and cultural

[1] For example, NAE (2004) stated that future engineers need to pay more attention to intellectual property, project management, multilingual influences and cultural diversity, moral/religious repercussions, global/international impacts, national security, and cost-benefit constraints. See also Catalano (2014).

rights. Therefore, "Everyone is entitled to these rights, without discrimination" (United Nations, 2019). The ethical philosophy that grounds human rights is debated, but it is frequently cited as grounded in the principles of human dignity, non-discrimination, and equality. Given that the universality of human rights rests on the premise that all people are born "free and equal in dignity and rights" (Art. 1, Universal Declaration), non-discrimination is a central principle. The fulfillment of both individual and group rights then provides the foundation for public welfare. Because engineering can affect both individual and group rights, it can also directly affect individuals' and groups' well-being.

In engineering education, human rights have also re-emerged as an explicit ethical lens for structuring discussions of professional responsibility, harm, and accountability beyond individual "micro-ethics." For example, recent work argues that the United Nations Universal Declaration of Human Rights can serve as a practical framework for engineering ethics education and course design, and "Engineering for human rights" has been articulated as a contemporary approach that links technical decisions to rights-holders and duty-bearers in real-world cases (Bielefeldt, 2019). Engineering directly shapes conditions for fulfilling rights — from the physical integrity protected by structural safety to the access rights enabled by infrastructure and technology.

Human Rights and Social Justice in Engineering Education

We also situate the human rights framework alongside the influential "engineering and social justice" tradition in engineering education (e.g., Bielefelt, 2019; Lynch, 2004). Social justice frameworks foreground structural inequity, oppression, and the politics of knowledge in engineering practice and education, whereas human rights frameworks more often emphasize codified entitlements, obligations, and accountability relationships (e.g., identifying duty-bearers and rights-holders). In this article, we analyze the process and products of a course that is explicitly framed around human rights; it seeks to connect classroom learning to professional norms and broader governance conversations.

While the target course is grounded in a human rights framework, we draw on insights from social justice scholarship to examine how students engage with issues of power and inequality. As one way of assessing this engagement, we analyze students' language development, attending to power hierarchies emphasized in social justice scholarship (Lucena, 2013).[2] In line with Riley (2008) and Claris and Riley (2012), we interpret such language use as reflecting students' critical thinking and reflexivity, which we treat as core indicators of socially engaged engineering education.

Engineering Ethics

There is a distinction between engineering ethics and engineers' ethics. Engineering ethics concerns macro issues, including the professional role of engineers within society (Herkert, 2001). Engineers' ethics deal with specific norms of conduct for "responsible"

[2] Human rights frameworks are not uncontested. Social-science critiques highlight recurring concerns abou t universalism, Western-centrism, gaps between formal recognition and lived protection, and the risk that r ights language can individualize structural problems. We therefore treat human rights here less as a final m oral endpoint and more as a disciplined vocabulary for naming harms, responsibilities, and competing obli gations, one that benefits from dialogue with critical approaches attentive to power, history, and inequality (Langford, 2018).

engineers. Normative ethics is translated into codes of conduct that lay out engineers' obligations and responsibilities to the public, clients or employers, and other engineers (Zandvoort & Brumsen, 2000). Although these "professional ethics" are useful within codes of conduct and industry guidelines, their narrowness often diverts attention from macro-ethical issues such as the role of engineering in society and the effects of the profession on the public interest, therefore failing to establish moral principles to guide the profession (Ladd, 1985). Engineering codes are nonetheless evolving toward greater recognition of human dignity and environmental protection, both of which align directly with human rights principles. The human rights-based pedagogy analyzed in this article links engineering practice to professional obligations and measurable performance standards integral to human dignity.

A Human Rights Approach to Engineering

A human rights-based approach to engineering complements these normative values by infusing human rights principles into the design criteria (Chacon-Hurtado et al., 2024). Human rights law creates a framework of norms and corresponding institutions to protect human dignity and safeguard peace and security (e.g., the UN Guiding Principles on Business and Human Rights, or *Ruggie Principles*, lay out this "Protect, Respect, Remedy" framework). Engineering for human rights is an approach for engineering design framed around concrete minimum standards based on human rights (Nickel, 2007); in practical terms, it not only prevents harm to people (negative rights) but also promotes the fulfillment of economic and social rights (positive rights), tackling structural injustice and inequalities. Thus, "Engineering for Human Rights" stands to transform engineering ethics education and practice by harmonizing traditional engineering ethics with the core obligations to respect, protect, and fulfill human rights.

A significant advantage of applying a human rights-based approach to interpreting engineers' professional obligations is that indicators and data central to the profession can be leveraged to translate principles into practice. The UN Sustainable Development Goals and the 2010 UN General Assembly Resolution 64/292 both recognize the human right to water and sanitation as being *"essential for the full enjoyment of life and all human rights*" (United Nations General Assembly, 2010). Engineering projects related to water are thus key to achieving the right in practice. [3] Common principles of universality, the interdependence of rights, accountability, participation, non-discrimination, and empowerment (Sano & Hansen, 2006) are central to achieving such rights. All of these principles are well-aligned with the principles of engineering for human rights, presented in the next section.

Previous Efforts to Incorporate Human Rights into Engineering Education

The discussion of human rights in engineering has been increasing over the past decade. A recent study analyzing 357 Web of Science records on "human rights" and "engineering" finds that most research examines the intersection of engineering with other fields such as sociology, medical ethics, genetics, and psychology (Bielefeldt, 2019). While human rights knowledge is already a formal requirement in social work, healthcare, and teacher

[3] See also Wyndham and Harris (2014).

education, publications that adapt engineering ethics to human rights have grown substantially over the past two decades (Bielefelt, 2019; Lynch, 2004).

These disciplinary trends are reinforced by broader curricular and institutional pressures. Surveys of leading engineering programs identify the role, responsibilities, and ethics of engineers as an anticipated curricular priority (Graham, 2018), and programs such as ETHOS, EPICS, and CARES demonstrate U.S. engineering students' appetite for co-curricular engagement with societal impact (Leydens & Lucena, 2017). Beyond individual programs, international engineering organizations — including the International Engineering Alliance and the World Federation of Engineering Organisations — have incorporated sustainability and societal responsibility into benchmark standards (Desha et al., 2019). Parallel curricular innovations have been documented across disciplines (Tranquillo, 2018; Brunell, 2019) and national contexts (Ramirez-Mendoza et al., 2020; Kopnina, 2018). We argue that these converging trends have galvanized teaching professionals to adopt new engineering paradigms focused on human and societal challenges — of which the course analyzed in this paper is one example.

Class Description and Pedagogy

In this article, we focus on the experiences and student artifacts from two consecutive semesters of the "Engineering for Human Rights" course (Spring and Fall 2025) offered at our institution. It has been open to engineering and non-engineering students, from sophomores to seniors, interested in the intersection of human rights (HR) and technology. Students explore the role of engineering in building a just society and develop the skills to assess the human rights and environmental impacts of engineering projects, including life-cycle thinking. The main idea is not only to cover fundamental concepts but also to provide a critical perspective on how to "re-engineer" projects to overcome such challenges. The class has been taught annually for four years (2021 to 2025), with 100 undergraduate students across a range of majors, especially from engineering, social sciences, and humanities. Engineering disciplines represented include Chemical Engineering, Electrical Engineering, and Civil Engineering.

The course consists of four essential modules: 1) foundational concepts of human rights and related ethical paradigms; 2) historical perspectives on the role of engineers in society; 3) human-rights-based approaches to engineering practice aligned with principles of distributive justice, participation, consideration of duty bearers, accountability, and indivisibility of rights; 4) the application of concepts through case-based learning. Modules 1 to 3 cover key concepts such as economic rights, social rights, cultural rights/community well-being, civil and political rights, group rights / Indigenous Rights, and intersectionality in human rights. The instructors have also focused on environmental aspects such as planetary boundaries and ecosystem services and integrated them with human rights assessments using lifecycle principles. Engineering ethics serves as a critical link between human rights and engineering covered in these modules. The class has discussed key ethical theories, presented a historical overview of engineering codes of ethics, and critically analyzed existing codes of ethics and engineering projects through a human rights lens.

The aforementioned themes are central to students' assignments, especially their weekly online discussion posts. Each week, students read or watch the assigned materials—including journal articles, reports from international organizations or NGOs, news articles, and documentaries—and post reflections on the online discussion board.

The thematic focus shifts substantially across the semester. Early weeks (Weeks 1-6) center on foundational human rights concepts and the history of engineering and society, while later weeks (Weeks 7-12) shift toward application-oriented content, such as the debate between the right to development and the human-rights-based approach to development, the lifecycle assessment, and critical thinking about human rights and engineering work.

In their posts, students identify key human rights issues and ethical dilemmas raised by the assigned materials, but—crucially—they also critically interrogate the arguments and assumptions embedded in those materials. Students develop their deliberative thinking skills in human rights and engineering by evaluating the materials' limitations, questioning their framings, and reflecting on how engagement with the materials shapes or shifts their own understanding. Students also respond to one another's posts, thereby engaging in active and interactive dialogue. This format encourages students to become knowledge creators—teaching each other, generating new ideas, and collaboratively refining arguments. This goal aligns with Claris and Riley's (2012) efforts to develop an engineering curriculum that builds students' critical thinking skills through reflective practices.[4]

Analyses: Natural Language Processing (NLP) and Qualitative Approaches

This study focuses on weekly discussion posts, as they provide valuable data for understanding key themes in students' critical thinking and for identifying patterns of change in students' perceptions toward human rights, sustainability, and engineers' roles over time. From Spring to Fall 2025, 12 students voluntarily consented to have their posts used in this study: 2 students from Spring 2025 (20 posts) and 10 students from Fall 2025 (96 posts), for a total of 116 posts. Given the relatively small sample (n=12), this study should be understood as a pilot study rather than a large-scale quantitative analysis. As such, the NLP findings should be treated as exploratory and descriptive, rather than as statistically generalizable. Student identities are anonymized as Student 1–12 in all figures. (Students 1–2 are from Spring 2025; Students 3–12 are from Fall 2025.)

We split the class in half to understand change over time but also to reflect the structural transition of the course. The first half of the course comprises foundational modules (Modules 1–2, Weeks 1–6) that introduce conceptual frameworks for human rights and engineering ethics. The second half of the course are applied modules (Modules 3–4, Weeks 7–12), which engage students in case-based analysis of real engineering

[4] Along with weekly discussion posts, students enhance their critical and creative thinking about how human rights and engineering intersect through case-study-based learning and a group project. This project analyzes the impacts on human rights, ethical considerations, and the environment that are addressed or overlooked in these projects or technological developments. Students also provide feedback to each group member through a peer-review system, which promotes leadership and active participation in class. Pritchard and Baillie (2006) emphasize that a new engineering curriculum respecting social justice can promote greater participation and inclusiveness in decision-making, science, and technology. Similarly, this class aims to have students use their critical thinking skills and knowledge from the course when evaluating the impacts of their engineering technology or projects as professional engineers or experts in the future. However, analyses of these other features of the course are outside of the scope of the current work.

projects through a human rights lens. We hypothesized that this pedagogical transition would be reflected in students' vocabulary.

Four Complementary NLP Approaches

We employ four complementary analytical approaches. Each addresses a distinct dimension of HR language learning. Together, they each partially compensate for the limitations of the others. As a data-informed pilot study, we do not present statistical significance; instead, we focus on broad trends from basic summary statistics and data visualizations.

First, to establish a baseline for HR vocabulary adoption, we use a deductively constructed HR lexicon of 56 terms spanning five conceptual categories: (1) Accountability/Duty-bearer, (2) Rights & Dignity, (3) Justice & Equity, (4) Participation & Employment, and (5) Environment & Sustainability.[5] This approach produces per-student density trajectories (Figure 1), weekly concept category trends (Figure 2), and a cross-cohort comparison (Figure 3), establishing overall patterns of HR vocabulary adoption as a foundation for the more refined analyses that follow.

Second, to address the concern that observed vocabulary shifts might reflect the language of that week's assigned readings rather than genuine learning, we develop a reading-controlled vocabulary analysis (described in detail below). This analysis categorizes student vocabulary into reading-echoed, conceptual transfer, and novel HR application, enabling us to separate passive repetition from active concept deployment.

Third, we compute cosine similarity between TF-IDF representations of each post and a reference corpus of core HR framework texts (i.e., the UDHR; Chacon-Hurtado et al., 2024; and Human Rights-Based Approach documents). This measure captures the extent to which student writing is thematically aligned with the overall vocabulary of the HR framework, rather than relying on any single term.

Fourth, we assess lexical sophistication through three measures: HR Type-Token Ratio (diversity), conceptual breadth (the number of the five HR framework categories engaged per post), and average IDF weight of HR terms used (specificity). Together, these four

[5] The five categories were as follows: Accountability/Duty-bearer (12 terms: accountability, accountable, duty, duty-bearer, obligation, obligated, responsible, responsibility, enforce, enforcement, comply, humanitarian), Rights & Dignity (11 terms: rights, dignity, right, entitlement, entitled, fundamental, universal, inherent, inalienable, indivisibility, indivisible), Justice & Equity (11 terms: justice, equity, equality, equal, fair, fairness, equitable, discrimination, nondiscrimination, intersectionality, oppression), Participation & Empowerment (11 terms: participation, participatory, empowerment, empower, agency, voice, activism, advocacy, inclusion, inclusive, democracy), and Environment & Sustainability (11 terms: environment, environmental, sustainability, sustainable, climate, ecosystem, planetary, lifecycle, carbon, emissions, ecological). They were constructed deductively from the six core conceptual pillars of the human rights-based approach articulated in Chacon-Hurtado et al. (2024) and the UDHR, including terms that are analytically distinct from general academic vocabulary and identifiable through exact string matching. A general "Engineering & Human Rights" vocabulary category was deliberately excluded from the lexicon because terms such as 'engineering,' 'design,' and 'technical' reflect the domain of the course rather than the HR framework itself, and their inclusion would conflate disciplinary familiarity with HR concept adoption. The term 'humanitarian' is included in the Accountability/Duty-bearer category, as it most closely aligns with the framework's emphasis on obligations toward those in crisis.

approaches provide convergent evidence for HR vocabulary learning that is more robust than any single method alone.

NLP Findings

Figures 1–3 present the baseline NLP analysis. Figure 1 shows per-student HR term density trajectories across the semester. HR term density is calculated as the proportion of words in each post that belong to the 56-term, five-category HR lexicon. Figure 2 shows the weekly average density for each of the five categories separately but averaged across all students. Figure 3 presents a comparison of the Spring 2025 and Fall 2025 cohorts.

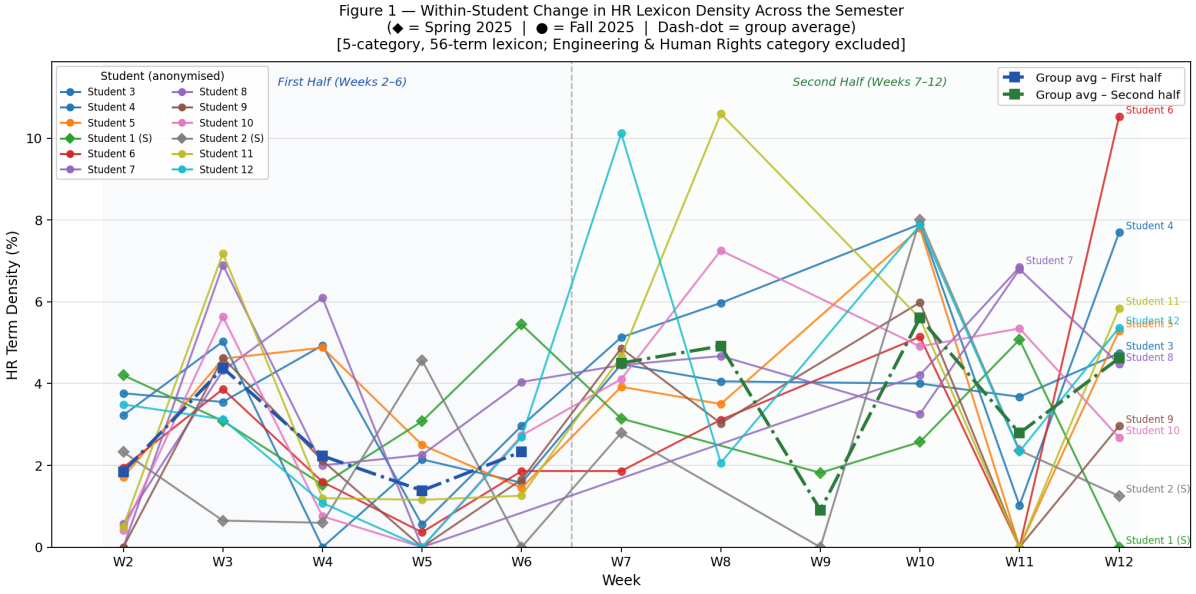

Figure 1: Within-Student Change in HR Lexicon Density Across the Semester

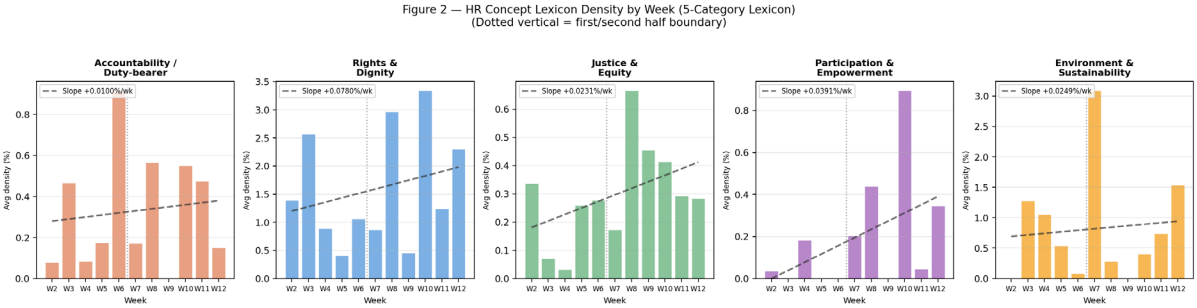

Figure 2: HR Concept Lexicon Density by Week Across All Posts

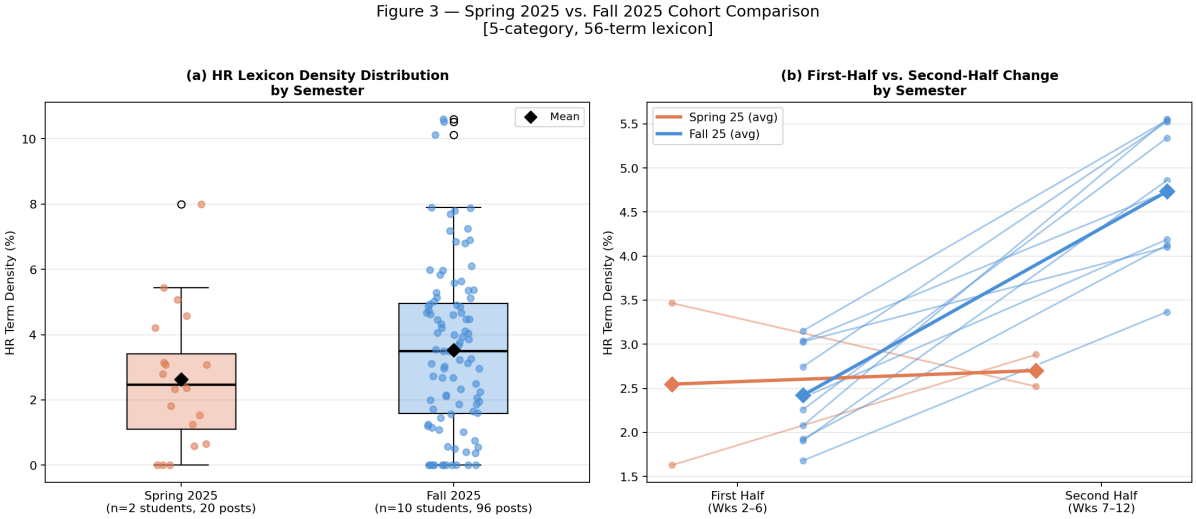

Figure 3: Spring 2025 vs. Fall 2025 Cohort Comparison

12345As Figure 1 shows, HR term density increases from the first half to the second half of the semester for 10 of 12 students. Group averages (dash-dot lines) show a clear upward shift. Figure 2 reveals that all five HR concept categories show positive trend slopes across the semester, with Rights & Dignity (slope = +0.078%/week) and Participation & Empowerment (slope = +0.039%/week) showing the most pronounced gains. Notably, Participation & Empowerment is the category with the largest proportional increase (from 5% to 33% of posts in the second half), consistent with the course's later emphasis on applied accountability and civic agency in engineering practice.

Figure 3 shows that both cohorts exhibit first-to-second-half increases in HR density: Spring 2025 (Δ+0.15%) and Fall 2025 (Δ+2.27%), providing preliminary directional support across cohorts. The larger increase in the Fall 2025 cohort (n=10) is more robust given the small Spring 2025 sample size (n=2).

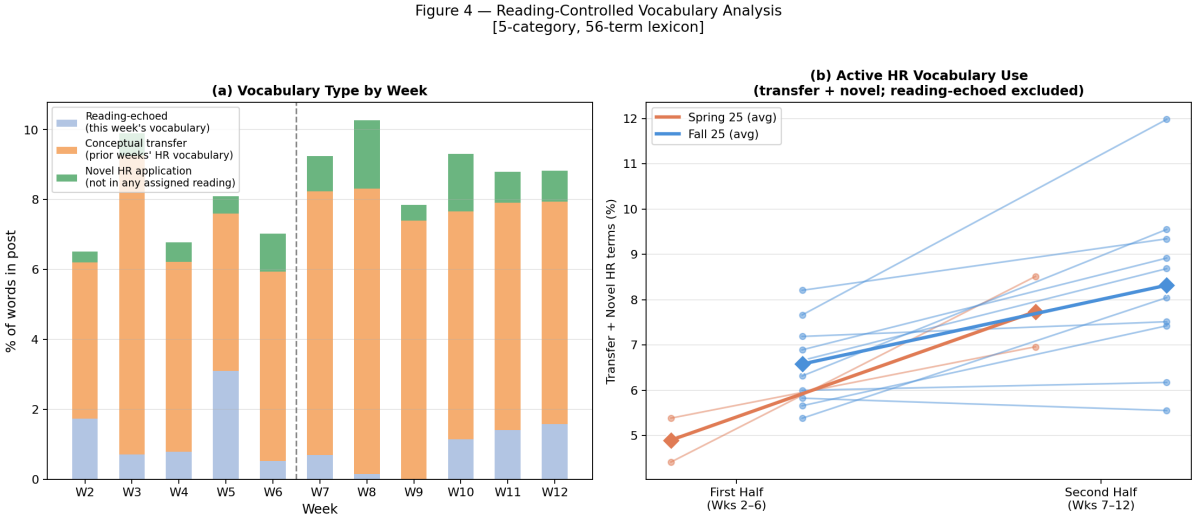

Figure 4: Reading-Controlled Vocabulary Analysis

To address the concern that observed vocabulary shifts might simply reflect students mimicking that week's assigned reading vocabulary, we developed a reading-controlled analysis that categorizes each HR-relevant word in student posts into one of three types, based on a weekly reading vocabulary derived from the syllabus.

Reading-echoed vocabulary consists of words appearing in that specific week's assigned readings. For example, a post in Week 5 that uses 'ethics,' 'cultural,' or 'moral' — terms foregrounded in that week's readings on engineering ethics and cultural relativism — is classified as echoing, reflecting the immediate textual environment rather than independent concept deployment. The most frequently echoed terms across the corpus include 'engineering' (36 instances), 'rights' (31), and 'ethics' (25).

Conceptual transfer refers to HR-relevant terms appearing in other weeks' readings but not the current week's, indicating that students are carrying concepts forward across modules. The most frequently transferred terms include 'rights' (253 instances), 'environmental' (57), 'development' (49), and 'justice' (21), each introduced in specific earlier modules but continuing to appear across the remainder of the semester.

The novel HR application consists of HR framework terms that do not appear in any week's assigned reading vocabulary, representing students' independent application of the framework. The most common novel-applied terms include 'responsibility' (22 instances), 'dignity' (17), 'accountability' (15), 'activism' (13), and 'duty' (9) — many of which are among the most analytically important concepts in the HR framework.

Figure 4 shows that reading-echoed vocabulary does not increase in the second half of the semester (Fall 2025: 1.51% → 1.21%). By contrast, both conceptual transfer (Fall 2025: 5.90% → 6.92%) and novel HR application (Fall 2025: 0.67% → 1.38%) increase. Figure 4(b) shows that most individual students increase their combined transfer + novel vocabulary use. This pattern provides direct evidence that the observed HR vocabulary growth reflects the accumulation and independent deployment of concepts introduced across the course arc, rather than mimicry of that week's assigned reading vocabulary. This constitutes a partial response to the concern about topic confound, though we acknowledge that the weekly reading vocabulary used here is derived from syllabus keywords rather than full reading texts, which we address under future directions.

Figure 5 — Semantic Similarity Analysis: Student Posts vs. HR Framework Reference Corpus

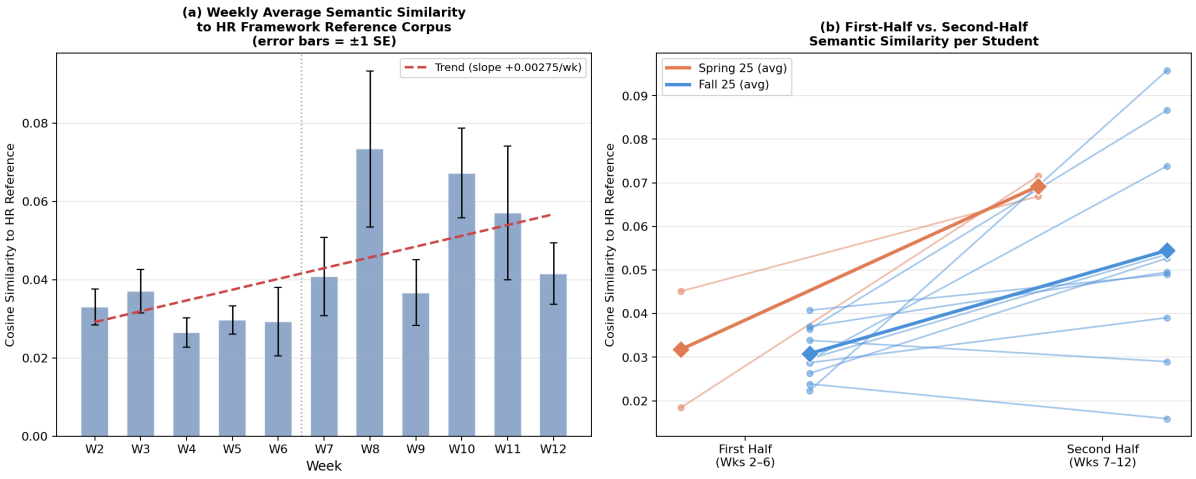

Figure 5: Semantic Similarity Analysis

To move beyond word frequency toward a meaning-based assessment of HR language use, we computed the TF-IDF cosine similarity between each student post and a reference corpus of core HR framework texts, including the UDHR preamble and key articles, central passages from Chacon-Hurtado et al. (2024), and foundational HRBA-to-development materials.

Semantic similarity to the HR reference corpus increases across the semester in both cohorts: Spring 2025 (first half [FH]: 0.032 → second half [SH]: 0.069, Δ+118%) and Fall 2025 (FH: 0.031 → SH: 0.052, Δ+67%). The week-by-week visualization in Figure 5(a) shows that similarity increases tend to accelerate in Weeks 9–12, corresponding to the course's applied focus on Engineering for Human Rights theory, tools for HR impact assessment, and case-based analysis.

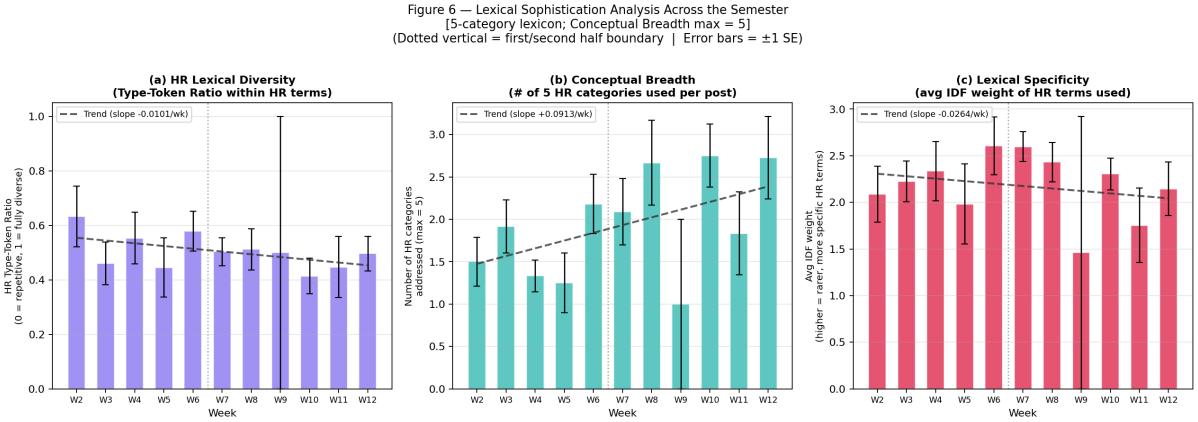

Figure 6: Lexical Sophistication Analysis

Three complementary measures of lexical sophistication are computed for each post. Findings are mixed across measures, reflecting the different dimensions of HR vocabulary use each captures.

HR Lexical Diversity (Type-Token Ratio; Figure 6a) measures the ratio of unique HR terms to total HR terms used per post. Contrary to our hypothesis, the TTR shows a modest decrease from FH=0.533 to SH=0.473 (Δ−0.061), indicating that students are deploying a narrower set of HR terms more frequently and repeatedly. Interpreted alongside the breadth findings, this pattern suggests consolidation around core HR concepts rather than broad lexical sampling.

Conceptual Breadth (Figure 6b) shows the most consistent and meaningful increase. In the first half, students' posts engage on average 1.63 categories, most commonly Rights & Dignity (68% of posts) and Justice & Equity (29%). Participation & Empowerment is nearly absent (5%), with only isolated terms such as 'advocacy,' 'agency,' and 'voice.' In the second half, average breadth increases to 2.35 categories (Δ+0.72). The most dramatic shift is Participation & Empowerment surging from 5% to 33% of posts, with new terms including 'participation,' 'activism,' 'empowerment,' and 'inclusion.' Environment & Sustainability also increases substantially (29% → 51%). This pattern suggests that students progressively integrate the more action-oriented dimensions of the HR framework as the course develops, consistent with Tibbitts' (2002) model of transformational human rights education.

Lexical Specificity (Figure 6c) measures the average IDF weight of HR terms used, where higher values indicate rarer, more framework-specific terms. The most common (low-IDF, generic) HR term is 'rights' (IDF=1.48, 71 posts). The most specific (high-IDF) terms include 'indivisibility' (IDF=4.66), 'ecosystem' (IDF=5.06), and 'oppression' (IDF=4.66). Average specificity shows minimal change (FH=2.24 → SH=2.20, Δ−0.04). Combined with the TTR decrease, this points to a pattern of consolidation: Students are using core HR terms more frequently and across more categories, but they are not markedly shifting toward rarer specialized vocabulary — consistent with what one would expect in a first course in HR-focused engineering education.

Qualitative Analysis

The qualitative dimension focuses on three excerpts of student discussion posts, each representing a distinct dimension of human rights learning. Excerpt 1 illustrates engagement with duty-bearer accountability and the indivisibility of rights. Excerpt 2 illustrates intergenerational equity and rights prioritization. Excerpt 3 illustrates professional identity re-orientation. In keeping with our de-identification of students throughout, we leave all three quotes without reference to their original poster.

> "*I had read the Human Rights Based Approach to Development. Though it was a shorter read, the website had provided much to think about. My initial thoughts were confusion because my immediate instinct was to think development was a guarantee of human rights, though upon reflection there are far more layers. For one, it is very much possible for development to come through the violation of human rights in others. The classic example of this would be the usage of slavery throughout history in order to build various structures, from as early as the pyramids, to the questionable practices of the 2022 World Cup. Development could also cause a high amount of emissions, which directly impact people through respiratory damage. As well as in the long term through the greenhouse effect. With this in mind it is absolutely necessary for there to be some sort of framework for development if we are to truly commit to upholding human rights*."

This excerpt illustrates duty-bearer accountability and the indivisibility of rights. The student works through the paradox that development can itself be a vehicle of rights violation, situating abstract rights language in historically grounded cases. The conclusion that "a framework for development" is necessary reflects an understanding of positive obligations, not merely negative ones — precisely what the reading-controlled analysis classifies as 'novel HR application.'

> "*I had read "Can Human Rights Deal with Existential Risks to Humanity and the Planet". This reading added in one last wrinkle in to human rights which I haven't actually considered despite it being one that in hindsight seems so obvious. The human rights of those who will inherit the earth. We have a very present-focused way of viewing human rights, which is undeniably important. Though this has lead to issues in jeopardizing many who are yet to reach adulthood, let alone be born. The clear example of this being fossil fuel emitting technology giving power but harming the environment. Myself personally I will side with the future over the present as many*

> *times as I can though factoring moments of conflict for human rights makes this harder. Prioritizartion in human rights is a cruel element.*"

This excerpt illustrates engagement with intergenerational equity and rights prioritization. The phrase "prioritization in human rights is a cruel element" signals a sophisticated recognition that rights frameworks must grapple with genuine trade-offs. This critical engagement with the limits of the framework reflects the kind of deep learning the course aims to foster (Claris & Riley, 2012).

> "*The article "The True Grand Challenge For Engineering: Self - Knowledge" was very interesting to read and opened my eyes to a whole new perspective about engineering. I learned about how engineering is impacting the lives of everyone. I am a multidisciplinary engineering major, so I think that this article was important for me to read. I never really considered engineering in the context of human rights or social sciences in general. Engineers should be encouraged if not required to take humanities courses to ensure that they are using their skills and knowledge to try to benefit everyone. This will allow for engineers to understand the societal impact of their work, as well as becoming more concerned with what, where and how they are creating their products. They will develop better critical thinking, communication, and ethical reasoning skills which is significant because it will assist in making the world a more equal and fair place.*"

This excerpt illustrates professional identity re-orientation — the shift from engineer-as-technical-specialist to engineer-as-rights-responsible-practitioner. The student's admission followed by a call for mandatory humanities requirements suggests that the course is successfully interrupting what Cech (2014) identifies as engineering's "culture of disengagement."

Taken together, these excerpts demonstrate the necessity of the mixed-method approach. The NLP analyses establish systematic patterns, including the surge in Participation & Empowerment breadth and increased novel application of terms like 'activism,' 'participation,' and 'duty.' However, without the qualitative analysis, we would miss the meaning and ethical complexity that word frequency metrics alone cannot reveal.

Conclusion

This work-in-progress study presents preliminary findings on the learning outcomes of an "Engineering for Human Rights" course using a convergent mixed-method approach combining four NLP techniques with qualitative close reading (n=12, 116 posts). Findings consistently indicate that students' human rights (HR) vocabulary increases in frequency, conceptual breadth, and semantic alignment across the semester. The reading-controlled analysis shows this growth is driven by conceptual transfer and novel HR application rather than passive reading-echo. The lexical sophistication analysis offers a more nuanced picture: While conceptual breadth increases substantially from the first half of the class to the second half of the class (FH=1.63 → SH=2.35 categories), HR type-token ratio decreases modestly and specificity remains stable. We interpret this pattern as consolidation around core HR concepts, consistent with what one would expect in a first course in human rights-focused engineering education.

Our findings contribute to the existing literature in several ways. First, we provide preliminary evidence that vocabulary adoption follows a developmental arc corresponding to the course's pedagogical structure, extending Chacon-Hurtado et al.'s (2024) theoretical framework with early-stage empirical grounding. Second, we demonstrate that a convergent multi-method NLP approach is both necessary and productive for assessing humanistic learning outcomes in engineering education. Third, we contribute to LEES research praxis by engaging with the epistemological tension between computational methods and critical humanistic scholarship.

The human rights framework carries limitations that merit acknowledgment. Human rights discourse has been critiqued for its universalist assumptions and Western-centric genealogy (Moyn, 2010), and in a pedagogical context, there is a risk that students learn to reproduce the vocabulary of rights without genuinely transforming their professional ethical orientation (Riley, 2008). Addressing this limitation is a central goal of our next steps, which include: (1) vector-based semantic analyses (word embeddings or topic modeling); (2) a systematic qualitative coding framework drawing on HR principles as analytic categories; and (3) a full-text reading-controlled analysis using actual assigned reading texts rather than syllabus-derived keyword lists.

Finally, the integration of human rights frameworks into engineering curricula is not politically neutral, particularly in the current U.S. higher education landscape where courses foregrounding social accountability face increasing institutional scrutiny. The "Engineering for Human Rights" course is grounded in internationally ratified legal norms and established professional engineering ethics obligations anchored in the UDHR and standards already recognized by ASCE and NSPE.

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AI Transparency and Critical Reflection

This paper used Claude (Anthropic) to find errors in Python-based NLP analysis scripts for four computational approaches, to revise them, and to visualize the results in six figures. To minimize the influence of any potential biases from the AI tool, the research team thoroughly reviewed and validated all analytical outputs against the raw data.

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