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Issues at the Intersection of Engineering and Human Rights: Insights from a Symposium of the National Academy of Engineering

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Issues at the Intersection of Engineering and Human Rights: Insights from a National Academies Symposium

Abstract

Engineering touches nearly every aspect of modern life, with the ability to help solve pressing global challenges or, conversely, to risk harms to society. While principles like ethics are gaining traction in engineering discourse, human rights offer a distinct and increasingly vital framework for engaging with complex engineering challenges. In November 2024, the National Academy of Engineering (NAE) and the Committee on Human Rights (CHR) of the National Academy of Sciences (NAS), NAE, and National Academy of Medicine (NAM) conducted a symposium on issues at the intersection of engineering and human rights.

The event brought together experts in the fields of human rights and engineering to explore how engineers can promote human rights and how human rights principles can inform engineering practice. It highlighted issues such as gaps in the provision of public infrastructure; the role of engineers in addressing climate issues; increasing public participation in engineering decision-making; and the integration of human rights into systems and product design. Sessions explored the evolving integration of human rights in the engineering profession and identified areas where further efforts are needed. The event also raised awareness of human rights issues among practicing engineers and within engineering education communities.

This paper and an accompanying presentation at the 2025 American Society for Engineering Education (ASEE) Annual Conference summarize the major findings identified, issues raised, and the suggestions for future action put forward by the symposium participants. These takeaways are framed using the human rights principles for engineering outlined by Chacón-Hurtado et al. [1]. These are also compared to prior ASEE literature on engineering and human rights, highlighting areas of interest and future exploration for engineering educators. This paper and presentation aim to catalyze further dialogue within ASEE and the broader engineering community about how engineering can contribute positively to the well-being of people and to advancing global health, prosperity, and welfare through the fulfillment of human rights.

I. Introduction

Engineering impacts nearly every facet of modern life, from infrastructure and technology to health care and environmental sustainability. Given this profound reach, how might engineers benefit from tools and expertise from the field of human rights—and vice versa? To explore this question, the National Academy of Engineering's (NAE's) program on Cultural, Ethical, Social, and Environmental Responsibility (CESER) [2] collaborated with the Committee on Human Rights (CHR) of the National Academy of Sciences (NAS), NAE, and National Academy of Medicine (NAM) [3] to convene cross-sectoral, interdisciplinary experts in human rights law, engineering, education, and more for a two-day symposium titled *Issues at the Intersection of Engineering and Human Rights* [4][1].

This paper highlights some of the research that has been done in the engineering and human rights space. It delves into the symposium, exploring the outcomes of the event particularly relevant to ASEE

[1] The views expressed in this paper, including those of the authors and any cited speakers, are their own and do not necessarily reflect the views of the National Academies of Sciences, Engineering, and Medicine.

audiences and the implications for future directions of work in these areas. Furthermore, this article aims to spark conversation amongst ASEE members on these important topics and serve as a resource for exploring them further in engineering education settings. The paper is organized as follows: Sections II and III provide general background on human rights and engineering and discuss how the National Academies have developed work in related areas. Section IV presents a summary and insights from the symposium organized under five themes. Sections V and VI delve into the discussion, followed by conclusions and areas for further development.

II. Background on Human Rights and Engineering

The term "human rights" refers to the body of international law that defines the rights and freedoms all people are entitled to simply by being human. This body of law includes the International Bill of Human Rights (made up of the Universal Declaration of Human Rights [UDHR], the International Covenant on Civil and Political Rights [ICCPR], and the International Covenant on Economic, Social and Cultural Rights [ICESCR]) as well as treaties such as the Convention on the Rights of the Child that are binding on governments, obliging them to act or refrain from acting in certain ways [5]. The United Nations Treaty Collection [6] lists which countries have signed, ratified, or acceded to specific treaties. Because engineering intersects with most facets of society, nearly every right enshrined in these documents has some relevance for engineering, including the rights to food, water, health, and freedom from discrimination.

Though human rights law is binding on states rather than individual actors, "human rights-based approaches" have been adopted across a variety of sectors—from health [7] to data [8] to business [9]—to help guide decision making with the goal of promoting human rights principles, including universality, equality, participation, accountability, and indivisibility [10]. In essence, human rights-based approaches—defined as frameworks that embed human rights principles as core structural components—involve taking steps to operationalize international law by putting human rights norms and standards into practice [11]. The Australian Human Rights Commission nicely illustrates this concept: if human rights law outlines *what* must be achieved for universal freedom and dignity, human rights-based approaches demonstrate *how* human rights can be realized [12]. Taking a human rights-based approach to engineering has the potential to benefit society as a whole by enhancing engineering outcomes and helping engineers tackle complex problems [1].

Human rights-based approaches to engineering are not new to ASEE. In 2002, Hoole & Hoole emphasized the importance of understanding human rights law for engineers working internationally and proposed teaching methods to address this need [13]. In 2004, Lynch argued that the UDHR serves as an irrefutable, secular benchmark for defining the basic human needs that engineering should address [14]. Building on these ideas, Bielefeldt (2019) advocated for integrating the UDHR into engineering ethics education to make it less U.S.-centric, encouraging engineers to adopt a global perspective [15]. In this study, Bielefeldt conducted a review of 357 references on Web of Science related to "human rights" and "engineering," finding that only 19% were categorized as engineering studies, compared to 52% in sociology, 46% in genetics, and 39% in medical ethics (note that many of these references fell into multiple categories). This analysis underscores the transdisciplinary nature of the field and suggests that other disciplines may engage more actively with the human rights implications of engineering than engineers themselves.

Recent efforts to integrate human rights into engineering education have been led by initiatives such as the Center on Forced Displacement at Boston University [16] and the Engineering for Human Rights Initiative at the University of Connecticut [17]. These efforts respond not only to the current trend in engineering education toward a socially relevant curriculum that promotes transdisciplinary learning and awareness of the social, technical, and cultural systems in which engineering operates, but also to the need for a focus on first principles in engineering design. Buchanan [18], for instance, argues that rather than emphasizing form and composition principles (such as aesthetics, usability, mechanical functionality, and market economics), engineering design should ground its first principles in human rights.

Chacón-Hurtado et al., of the Engineering for Human Rights Initiative, have recently developed a comprehensive framework for human rights-based approaches to engineering [1]. This framework positions human rights as a valuable complement to established discussions on sociotechnical systems and responsibility in engineering, examining differences and similarities with related fields like engineering ethics, humanitarian engineering, and sustainable development. The authors argue that incorporating concrete human rights metrics, laws, institutions, and networks can enrich and advance these conversations in a pragmatic way.

In practice, the proposed framework outlines three core engineering duties: preventing harm (preventive approach), remedying harm when it occurs (restorative approach), and proactively fulfilling human rights (proactive approach). These duties are grounded in five core human rights principles: distributive justice, broad participation, explicit consideration of duty-bearers, accountability, and the indivisibility of rights. A 2022 ASEE conference paper explores the practical applications of this framework in engineering classrooms [19], and its structure is illustrated in Figure 1 below.

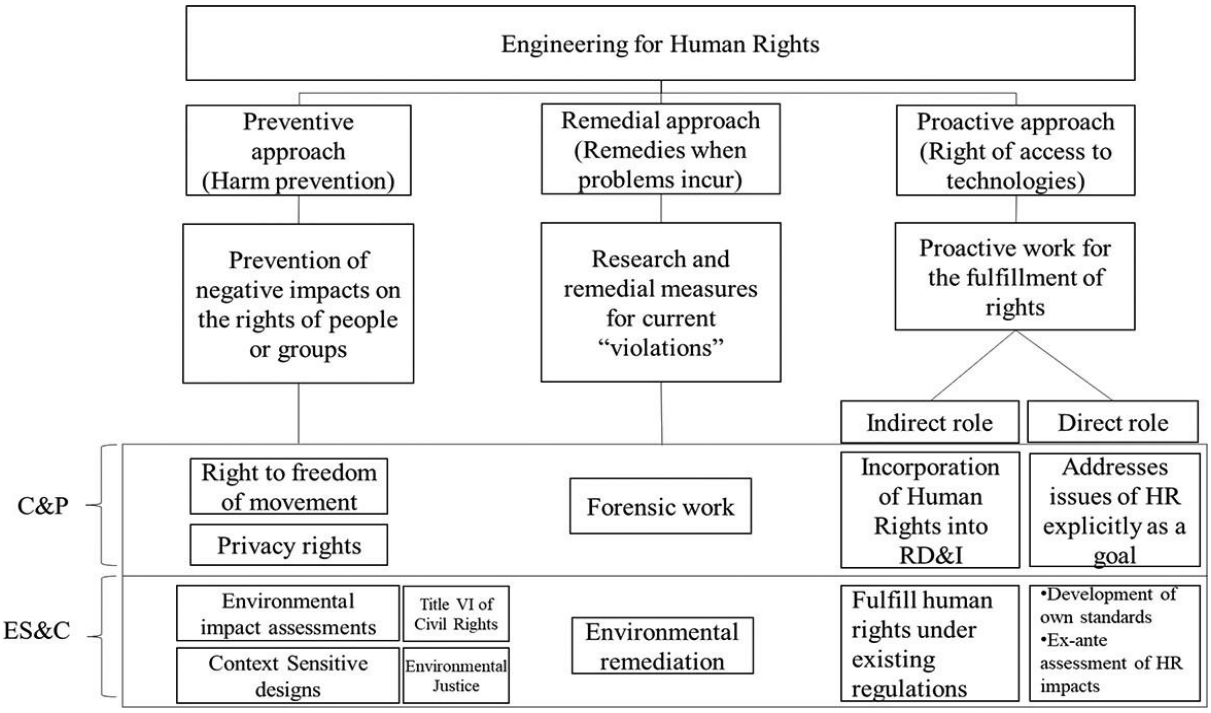

Figure 1. Chacón-Hurtado et al. [1, p. 17] [Figure 1] "A proposed framework of Engineering for Human Rights...C&P: civil and political rights; ES&C: economic, social, and cultural rights; RD&I: research, development, and implementation of projects and technologies; and HR: human rights."

III. History of Human Rights and Engineering at the National Academies

National Academy of Engineering

While direct engagement with human rights is a new focus for the NAE, the organization has a long history of addressing engineering's societal impacts. In the 1980s and early 1990s, the NAE published reports such as *Hazards: Technology and Fairness* (1986) [20], *Engineering and the Advancement of Human Welfare* (1989) [21], and *Engineering as a Social Enterprise* (1991) [22]. These reports laid the groundwork for exploring the broader ethical and social dimensions of engineering.

In 2003, a conference titled *Emerging Technologies and Ethical Issues in Engineering* [23] played a role in the transfer of Case Western Reserve University's Online Ethics Center (OEC) to the NAE. Then-President of the NAE, Dr. William Wulf, established a committee to guide the Academy's work on ethics, leading to the launch of the Center for Engineering Ethics and Society (CEES) in 2007 [24]. CEES managed the OEC and published influential reports, including *Engineering, Social Justice, and Sustainable Community Development* (2010) [25] and *Infusing Ethics into the Development of Engineers* workshop (2016) [26]. In 2018, the OEC returned to university stewardship at the University of Virginia under Dr. Rosalyn Berne's leadership [24].

During this period, the NAE also explored the intersection of peacebuilding and engineering. In December 2007, the NAE partnered with the U.S. Institute for Peace (USIP) and Google to host a workshop on *The Use of Information and Communication Technology in Peacebuilding* [27], addressing issues like mobile phone use in election monitoring. This collaboration evolved into the 2011 launch of the *Roundtable on Technology, Science, and Peacebuilding* [28], which sponsored four workshops in 2012 focused on topics such as agricultural extension systems, data sharing, operational systems engineering, and conflict monitoring [29], [30], [31], [32].

The NAE's latest initiative—the Cultural, Ethical, Social, and Environmental Responsibility in Engineering (CESER) program [2]—which launched in 2020, builds on this work of socially responsible engineering. A 2024 ASEE article by Gibson and Butler [33] detailed the CESER program's motivations and goals. The symposium on *Issues at the Intersection of Engineering and Human Rights* was CESER and CHR's inaugural collaboration. The goals of this symposium were to raise awareness of the role engineers play in protecting and promoting human rights, as well as explore how rights-based approaches to engineering can help address urgent challenges by convening groups of stakeholders that may not normally have opportunities for dialogue with one another, like human rights experts and engineers.

Committee on Human Rights

The Committee on Human Rights (CHR) is a standing membership committee comprised of elected members from the NAS, NAE, and NAM and is supported by a staff of human rights professionals. Founded in 1976, the CHR 1) "advocates in support of colleagues subjected to serious human rights abuses worldwide, with a focus on individuals targeted for their professional activities or the exercise of other internationally protected rights", 2) "assists professional colleagues under threat by linking them to pro bono legal and other support services", and 3) "raises awareness of issues at the intersection of science, technology, health, and human rights" [3].

While the majority of CHR's work has typically concentrated on the first two areas, it is increasingly interested in the third point—raising awareness by developing campaigns, resources, and projects that clarify the connections between science and engineering and human rights, and in doing so, empowering scientific and engineering professionals to engage with the field of human rights and pursue justice. In

2019, for instance, the CHR conducted a symposium on digital technologies, exploring the powerful tools offered by digital technologies for advancing human rights, which also pose significant challenges, including disinformation, surveillance, violence incitement, and discriminatory access [34]. In 2023, CHR collaborated with the Center on Forced Displacement at Boston University to develop pilot courses meant to help prepare science, technology, engineering, mathematics, and medicine (STEMM) undergraduate and graduate students to address challenges of forced displacement. The pilot courses were co-developed by experts in the fields of engineering, pedagogy, demography, migration, forced displacement, and human rights and have thus far been offered in engineering departments at four universities across the country [35], [36].

IV. Symposium "Issues at the Intersection of Engineering and Human Rights"

Planning

This collaboration between NAE's CESER Program and the CHR stemmed from a shared interest in exploring the intersection of engineering and human rights, was supported by a gift from an elected member of the NAE and was guided by a planning committee.

A total of 26 panelists participated, primarily representing academia, alongside speakers from private industry, NGOs, and nonprofits. Their expertise spanned multiple disciplines, including engineering education, engineering practice, human rights law, and other related fields. Educational themes were woven throughout each of the symposium's discussions due to the large presence of speakers from academia. The sessions were as follows:

- Bridging Human Rights and Engineering
- Human Rights and Engineering Education
- Engineering to Promote Climate Justice
- Addressing Inequities in Public Infrastructure
- Activity Session: A Case Study on a Human Rights-Based Approach to Engineering and Inclusive Transportation
- Participation and Inclusion in Engineering Decision-Making
- Seeking Justice and Remediating Human Rights Harms
- Integrating Human Rights Principles into Systems and Product Design
- Activity Session: How to Conduct a Human Rights Assessment of AI

The event garnered significant attendance from both virtual and in-person audiences: approximately 500 total participants. Viewership data revealed online participants from 21 countries and 35 U.S. states (excluding in-person attendees), underscoring the event's wide reach and interest.

Takeaways from the symposium

Several of the issues raised in the symposium are of direct relevance to engineering educators. The event was designed to be action-oriented, providing concrete examples for students, educators, and practitioners to integrate into their own work. Human rights-based approaches to engineering problems were compared to other relevant approaches like ethics and posed not as replacements to these lenses, but as complements backed by international law. Speaker Maya Carrasquillo, University of California, Berkeley, emphasized that "bridging engineering and human rights can continue to build upon the ethical and justice framings

that challenge engineers to think about the complexity and opportunities of operationalizing human rights."

The following sections summarize some of the perspectives and insights offered by symposium participants, framed by the terms used by the Human Rights-Based Approaches to Engineering principles outlined by Chacón-Hurtado et al. [1]: 1) distributive justice, 2) broad participation, 3) explicit consideration of duty-bearers, 4) accountability, and 5) indivisibility of rights for all actors involved. While this framing is a helpful organizational tool, it is important to note that not all examples of engineering and human rights fit neatly into one of these categories—many span across several principles. A more in-depth exploration of the issues identified can be found in the videos of the symposium posted online[2], as well as in the symposium proceedings, once publicly available in mid-2025 on the National Academies Press website.

1) Distributive justice

This principle asserts that engineering work must ensure equitable distribution of benefits, risks, and harm resulting from engineered systems across all sectors of societal groups and generations [1]. The symposium highlighted how this distribution often falls short of equitable outcomes, particularly for historically neglected groups, and ways engineers may help reduce these disparities.

For example, Kimberly Jones from Howard University noted that despite years of regulations and advancements in water resource engineering, "large percentages of people in this country and around the world do not benefit from all of our excellent engineering and all of our science-backed regulations every day." Her observation directly connects to the human right to water and sanitation recognized by the United Nations in 2010 [37]. Jones emphasized that engineers can make a difference by collaborating with policymakers, social scientists, and affected communities to design and implement infrastructure that targets underserved areas. They can advocate for policy reforms that ensure fair access to affordable, safe water and incorporate best practices and technologies to improve water reliability and safety. Engineers can also contribute to capacity building by training and upskilling local community members to maintain and manage water systems sustainably, ensuring that solutions are both effective and long-lasting. Jones has done much of this work herself throughout her 30+ year career in civil and environmental engineering, not only as a professor, but also as former Chair of the U.S. Environmental Protection Agency's Science Advisory Board and Chair of the National Science Foundation's Advisory Committee on Environmental Research and Education, where her engineering expertise has directly influenced public policy and directions of research funding.

As a second example, Carlton Waterhouse, an international expert on environmental law and environmental justice also from Howard University, discussed the disproportionate burden of environmental contamination on neglected and lower-income communities. He noted that while the industrialization of American society produced significant wealth for some groups, the consequence is that some people are experiencing exposure to toxic waste every day. He highlighted examples of massive mining sites from WWII-era defense production, like 500 abandoned uranium mines on the Navajo Nation that have yet to be remediated [38]. To ensure justice when it comes to these environmental burdens, Waterhouse said that engineers can help develop mitigation solutions that align with the standards that would be applied to wealthy communities. "Because the truth is, if a wealthy community is happy to have it, it probably is okay for the poor communities too, right? But if it's designed that it's only good enough for the poor communities, it's probably not good enough." To work towards this goal, "we

[2] https://www.youtube.com/@theNAEng/playlists

need engineers and scientists who are thinking about how to ethically create the kind of world they want to live in, whatever neighborhood they happen to be in," he said.

2) Broad participation

This second principle asserts that members of society have the right to be actively involved in all phases of engineering projects [1]. This ties closely to Article 27 of the UDHR which states that everyone has the right to "share in scientific advancement and its benefits" [39]. In the symposium session on "Participation and Inclusion in Engineering Decision-Making," Amy Smith, Founding Director of D-Lab at the Massachusetts Institute of Technology, stated that "it is incumbent on the engineers to think about what their role in problem-solving is...but make sure they bring people into it." Smith also pointed to Article 15 of the International Covenant on Economic, Social and Cultural Rights, which respects the "freedom indispensable for scientific research and creative activity." What Smith expressed as the "right to creativity" confers intangible benefits to those who participate in the creative design process, such as feelings of accomplishment, pride, joy, and agency, providing a framework for understanding the value of participation in engineering.

Participatory approaches can transform engineering from a top-down practice into a collaborative effort that empowers communities and upholds human rights. Julie Owono, Executive Director of Internet Sans Frontières and an Inaugural Member of the Meta Oversight Board, emphasized the transformative power of public participation in decision-making with the Oversight Board. This board, founded in 2020, is comprised of experts from around the world and serves as the external and independent "Supreme Court of Facebook," providing both binding and non-binding recommendations to Meta in order to uphold rights. They have a "public comment" option which allows individuals and organizations to contribute their perspectives to the Board's deliberations. Public comments have shaped the Oversight Board's recommendations to Meta on numerous occasions, Owono explained, such as a recommendation for Meta to improve automated detection of images with text overlay, ensuring that breast cancer awareness posts are not mistakenly flagged for nudity violations. As a result, Meta enhanced human review processes and developed a new health content classifier, leading to the review of 2,500 posts over 30 days and improved identification of breast cancer-related content.

Similarly, Betsy Popken, Executive Director of the Human Rights Center at the University of California, Berkeley, stressed the importance of incorporating user feedback as a form of participation in assessing the human rights impacts of large language models (LLMs). She noted that this feedback, particularly in high-risk professional contexts, can help ensure these tools are developed and deployed responsibly. Bernard Amadei, Founding President of Engineers Without Borders USA, further reinforced this participatory ethos, noting, "We need young people to come and tell us what they want and how they are going to address the problems of the world that we are facing today." Tamara Brown, former Vice President of Sustainability at Linde, emphasized the importance of accountability in preventing communities from being excluded. "If we want to develop applications that are very successful, we cannot develop those applications and leave communities behind," she argued. These reflections illustrate how prioritizing participation ensures that engineering solutions are not only inclusive but also contextually relevant and sustainable.

3) Explicit consideration of duty-bearers

This third principle articulated by Chacón-Hurtado et al. states that engineers must share responsibility with states and other stakeholders to uphold human rights [1]. Symposium speaker Theresa Harris, Director of the Center for Scientific Responsibility and Justice at the American Association for the Advancement of Science, underscored the shared responsibility of engineers to align their professional

obligations with broader societal goals, stating that "scientific [and engineering] responsibility is the duty to conduct and apply science with integrity, in the interest of humanity, in a spirit of stewardship for the environment, and with respect for human rights."

Katie Shay, Associate General Counsel and Director of Human Rights at Cisco, highlighted how engineers at Cisco worked alongside human rights lawyers to serve as duty bearers in the development and governance of responsible artificial intelligence (AI). By applying the UN Guiding Principles on Business and Human Rights, Cisco developed a comprehensive human rights program that integrates these principles into AI design and corporate decision-making. Engineers played a critical role in this process by collaborating to establish specific requirements for AI development that embed transparency, accountability, security, fairness, privacy, and reliability throughout the lifecycle of AI models. These principles translate into practical controls that engineers use for model creation and data training, ensuring security, privacy, and human rights are upheld by design.

The importance of engineers embracing their role as duty bearers and working together with other duty bearers was further highlighted in an interactive exercise on human rights and the design of inclusive transportation systems. For example, one breakout group identified municipal governments as the primary duty bearers, responsible for implementing accessible infrastructure, such as sound systems for visually impaired passengers or shelters at transit stops. However, engineers play a pivotal role in translating these policy commitments into practical, innovative designs that address both visible and invisible disabilities. Another group explored how engineers could design ramp-molding tools to empower communities to maintain infrastructure while ensuring accountability, or they could create scalable systems like dynamically expandable transportation fleets. By embedding accessibility into the design process, engineers can collaborate with municipalities, transportation operators, and community members to co-develop solutions that are contextually relevant and sustainable.

4) Accountability

While the principle on duty-bearers emphasizes who should be responsible for upholding human rights, the "accountability" principle focuses more on the means by which to uphold rights, stating that evidence-based monitoring must guide engineering decisions [1]. Jay Aronson, Professor of Science, Technology, and Society and Founder and Director of the Center for Human Rights Science at Carnegie Mellon University, warned of the dual-edged nature of engineering and technology, noting that "the exact same technologies and systems that can promote and protect human rights can also be used to violate human rights." This duality underscores the need for intentional design processes that consider both potential benefits and risks. In cases of remediation of harms, engineers can serve as expert witnesses in instances where human rights have been violated as a result of engineered systems.

José Torero, Professor and Head of the Civil, Environmental, and Geomatic Engineering department at University College London, uses his expertise as a fire safety engineer to uncover systemic failures in safety design and management that have led to preventable tragedies, such as the mismanagement of Chilean prisons, unsafe regulatory practices in Paraguayan supermarkets, and inadequate fire safety in South African factories. By identifying how flawed building construction has endangered vulnerable populations, he has shifted accountability from individual managers to systemic oversights and emphasized the ethical responsibility of engineers to advocate for human rights through safer designs and practices.

An interactive exercise on human rights assessments of large language models (LLMs) gave symposium attendees practical insights into how the principle of accountability can be applied in engineering and technology development. Moderators Betsy Popken (UC Berkeley) and Lindsey Andersen (Associate

Director for Human Rights at Business for Social Responsibility) guided participants through their methodology for human rights assessments, including identifying and prioritizing risks, assessing their severity, and recommending mitigation strategies. Participants worked in groups to analyze a real-world scenario involving LLMs used by journalists reporting on COVID-19, identifying risks to human rights such as the right to health, privacy, and nondiscrimination. Audience participants brainstormed actionable recommendations to hold accountable engineers, media organizations, and policymakers, such as ensuring data accuracy, establishing validation protocols, and embedding transparency into AI systems.

5) Indivisibility of rights

The final principle from Chacón-Hurtado et al.'s framework is indivisibility, the concept that no right can be fully realized in isolation from others. To implement this principle, engineers must adopt holistic approaches to their work, avoiding siloed strategies that might uphold one right at the expense of violating another [1]. At the symposium, Davis Chacón-Hurtado, Assistant Professor of Civil and Environmental Engineering and Co-Director of the Engineering for Human Rights Initiative at the University of Connecticut, explained this principle by discussing transportation as an *instrumental* right. Although the right to transportation is not enshrined as a *fundamental* right in the UDHR, access to transportation enables other fundamental human rights such as education, healthcare, and employment. Drawing from examples in rural Andean communities, he described how inadequate transportation infrastructure disproportionately impacts vulnerable populations, limiting timely access to schools, healthcare facilities, and economic opportunities. These impediments, he noted, are mirrored globally in circumstances where disproportionate burdens are placed on neglected groups. Chacón-Hurtado emphasized that engineers play a critical role in designing accessible and safe transportation systems that ensure infrastructure development benefits all communities without perpetuating or creating human rights violations. By addressing transportation, for instance, as a bridge to multiple rights, engineers can advance the indivisibility principle, recognizing that fulfilling one right inherently supports the realization of many others.

Carlton Waterhouse's remarks further illustrated the importance of indivisibility. Responding to a question about how mitigating past environmental harms can lead to gentrification and the displacement of affected communities, Waterhouse acknowledged the challenge of balancing rights. Efforts to uphold the right to health and a clean environment, for example, can inadvertently violate the right to housing if mitigation projects result in displacement. To address this, he explained that engineers working on mitigation should partner with lawyers, city officials, and policymakers to accompany these projects with harm reduction policies such as locking-in tax rates for long-term residents. This example highlights not only how rights are interconnected, but also how the principles used to uphold them—such as indivisibility and the responsibility of duty-bearers—are deeply interdependent.

V. Discussion

Bridging Engineering and Human Rights

An important theme that emerged from the symposium, consistent with the literature, was how understanding human rights and sharing a common language with human rights experts could benefit the field of engineering, and thus, society. By integrating human rights, engineers are provided with additional ethical guidance [15], enhance their communication skills [40], develop more holistic designs, and contribute to the overall improvement of the profession [14]. Seldom discussed in the literature, however, are the benefits that engineering frameworks could impart to the field of human rights. These

two-way benefits were touched upon at the symposium by speakers like Tyler Giannini, Clinical Professor of Law at Harvard Law School. Giannini discussed how human rights frameworks often operate at a broad conceptual level, whereas engineering requires detailed technical implementation. Engineers can play a crucial role in translating high-level human rights principles, such as the duty to respect, protect, and fulfill, into concrete solutions that businesses and governments can adopt. Without this shared, bilateral understanding, human rights law may remain too abstract to influence engineering decisions, and technical solutions may fail to account for ethical considerations. Giannini also highlighted that the human rights field has traditionally been reactive, focusing on addressing violations rather than preventing harm. Engineers, however, bring a solutions-oriented approach that can help shift human rights work toward proactive interventions, such as designing infrastructure that prevents displacement or developing technologies that expand access to essential services.

This evolving dialogue between engineering and human rights also reflects a broader shift within engineering ethics toward social responsibility and public welfare. Mitcham [41] describes a four-phase development of engineering ethics that contextualizes this transformation. First is implicit ethics, where professional behavior is mainly about loyalty to peers and employers as well as respect for social hierarchy. Second is ethics as loyalty, where codes of ethics become tools for differentiation, professional growth, and prestige, although loyalty is still considered the main obligation. Third, ethics of efficiency calls for freeing engineers from being subservient to business interests, with an optimistic view of technocracy as the driving force behind human progress. Finally, the fourth phase—the ethics of public safety, health, and welfare—arises from the tension between technology and democracy, especially after WWII, where engineers become more aware of the social impact of their work and their responsibilities. In the early 21st century, for example, there is concern that human-driven effects on the environment are leading to adverse outcomes.

In summary, framing engineering as a valuable contributor to human rights—rather than focusing solely on engineering's shortcomings—may be an effective way to engage engineers, discuss designs holistically, and foster their commitment to the field.

Human Rights as Normative and Voluntary Guidance in Engineering Design

A key point that emerged from symposium discussions was the utility of human rights frameworks for advancing justice, given that they are based on concrete legal precedent rather than appealing to individual morality, values, and compassion. This distinction could make human rights an enduring framework that transcends shifting national, cultural, or political discussions and focuses on development and justice for everyone, both in the short and long term. That said, many previous efforts in this area focus on the UDHR as the primary guiding human rights framework. Bielefeldt [15] used the UDHR as a lens for engineering ethics, with examples of how engineering ethics relates to the rights to nondiscrimination, life and security, privacy, property ownership, work, and a basic standard of living. Lynch [14] used the UDHR as a reference point for the "basic human needs" that engineers aim to serve.

While the UDHR may be the most well-known delineation of basic human rights amongst non-human-rights-experts, it may be less understood that the UDHR is not legally binding. It was adopted by the United Nations General Assembly in 1948 as a common standard of human rights but does not have the force of a treaty. Similar issues are highlighted with the UN's Sustainable Development Goals (SDGs) in the literature—they are non-binding, and thus can be inconsistently applied by governments and businesses [1]. The UDHR did however lay the foundation for legally binding human rights conventions and treaties, such as the International Covenant on Civil and Political Rights (ICCPR) and International Covenant on Economic, Social and Cultural Rights (ICESCR). Authors like Hoole [40] have incorporated

a variety of human rights conventions and treaties into their engineering curricula, such as the International Bill of Human Rights (comprised of the UDHR, ICCPR, and ICESCR), International Humanitarian Law, and the International Labor Organization Conventions. Chacón-Hurtado et al.'s framework [1; Figure 1] situates engineering activities specifically in relation to civil and political rights (C&P), and economic, social and cultural rights (ES&C). Bielefeldt [15] points out that Americans tend to focus primarily on civil and political rights, in reference to the U.S. Bill of Rights, rather than the full spectrum of human rights.

It is important that future work continues to go beyond the UDHR to connect engineering to legally enforceable human rights frameworks. This was a particular focus of the symposium: a variety of these conventions and treaties were discussed, with speakers specifying which ones are binding or voluntary, which duty-bearers are obliged to uphold them, and where engineers play a role. For instance, symposium speaker Shareen Hertel, co-author of the Engineering for Human Rights framework [Fig. 1] and Wiktor Osiatyński Chair of Human Rights and Professor of Political Science at the University of Connecticut, also observed that ES&C rights are often overlooked in U.S. rights discourse, even though engineering is uniquely positioned to help measure and improve access to these fundamental rights. Hertel explained that engineers can uphold ES&C rights—such as the right to health or the right to housing—by adhering to ethical and professional responsibilities, addressing the social and environmental impacts of their work, and ensuring safety and well-being across stakeholders and supply chains. Engineers' role extends to compliance with legal and industry standards, managing reputational risks, and fostering positive outcomes such as improved productivity, policy coherence, and interdisciplinary collaboration. As another example of ES&C rights, speaker Amy Smith cited Article 15 of the ICESCR, which enshrines the right to participation in science as well as the right to benefit from the creative process, as both a justification for and outcome of expanding the ability to participate in engineering decision-making.

Previous efforts in this direction also cite Article 15, which laid the foundation for the American Association for the Advancement of Science's 2017 Statement on Scientific Freedom and Responsibility [15], [42]. This statement emphasizes that scientific freedom and responsibility are inherently connected and that recognizing this relationship is crucial, as scientific and engineering advancements have the potential to bring both significant societal benefits and unintended harms. Importantly, the symposium touched on other human rights laws that have been underexplored in the literature. For example, the Convention on the Rights of Persons with Disabilities (CRPD) [43] was a key topic of the day one participatory activity on inclusive transportation systems, and the UN Guiding Principles on Business and Human Rights (UNGPs, or the "Ruggie" Principles [44]) were discussed throughout the event, particularly by Katie Shay at Cisco, where these principles have been voluntarily adopted. Shay explained that most large companies voluntarily accept the UNGPs, with the pressure to do so coming from public opinion and shareholders rather than legal action. If engineers have an understanding of whether or not their companies have opted into the UNGP, this can give them leverage to help ensure that their engineering systems are upholding human rights and make it easier to work alongside human rights attorneys like Shay to design responsible AI, for instance. In the case of the CRPD, the U.S. has signed but not ratified the convention, meaning that the U.S. supports the goals of the CRPD, but is not legally bound to them. Other countries, however, have ratified the CRPD. Thus, understanding these distinctions is important for engineers advocating for things like accessibility and inclusion in their work, especially when working internationally. This knowledge may be used to hold their companies and clients accountable as possible duty-bearers.

Advancing Human Rights Through Concrete Actions

A key theme emerging from the symposium was the need to focus on concrete actions and takeaways that practicing engineers can implement into their own work. In the literature, Hoole [40] outlined nine scenarios for engineers to be involved in human rights situations, and Chacón-Hurtado et al. [1] mapped concrete engineering tasks onto their framework of preventative, remedial, and proactive approaches to human rights (Figure 1). Tangible examples of engineers working on human rights issues from the symposium included the collaboration of engineers with policymakers and local communities to design infrastructure projects that prioritize underserved areas, as Kimberly Jones emphasized regarding access to safe water. Engineers can advocate for policies that ensure reliable and affordable water access while also training community members to maintain these systems for long-term sustainability. Engineers can design environmental harm mitigation solutions that meet the same standards no matter which community they are applied in, as Carlton Waterhouse suggested. They can also integrate participatory design approaches, ensuring that communities affected by engineering projects are involved in decision-making. Amy Smith and Julie Owono highlighted the importance of public engagement, showing how participatory approaches in fields like online privacy and international development can lead to more effective solutions. Engineers can further uphold human rights by embracing their role as duty bearers, aligning their work with legal and ethical obligations, as illustrated by Katie Shay's example of embedding human rights principles into Cisco's AI development. Finally, engineers can play a key role in accountability by assessing risks and advocating for uniformly safer and fairer engineering practices, as seen in José Torero's work uncovering fire safety violations.

While the event yielded a number of positive outcomes, areas for improvement were also identified. Despite achieving broad international viewership online, most speakers were U.S.-based, suggesting a need for greater inclusion of international perspectives in future events. This is especially relevant given the applicability of a human rights framework grounded in international law, as noted by Bielefeldt [15] and Hoole & Hoole [13]. These frameworks advocate for approaches that incorporate multiple, global perspectives on engineering to ensure their broader legitimacy and relevance. The symposium primarily featured academic speakers, highlighting an opportunity to better incorporate additional perspectives in subsequent gatherings. For example, the NAE itself mandates that half of its elected Members come from the private sector positions in order to engage more effectively with industry leaders and practitioners. Future initiatives should leverage this strength to bring industry representatives and practicing engineers—particularly those integrating human rights principles into their work—into the conversation. By fostering collaboration between practitioners and educators, these efforts could better align educational objectives with industry needs while addressing practical constraints. This approach would help prepare students to enter a workforce committed to upholding, rather than—however inadvertently—undermining human rights.

VI. Conclusions and Future Work

This symposium showcased key research and themes at the intersection of engineering and human rights, bringing together multiple stakeholders, including engineering educators and human rights lawyers, who seldom engage directly with one another. The event reflected the National Academies' role in fostering cross-sector collaboration and in creating platforms for dialogue and dissemination of knowledge to broader audiences that might otherwise remain disconnected from these critical developments in this space.

The intersection of engineering and human rights presents an opportunity to strengthen the role of engineers as key contributors and duty-bearers in building a prosperous and fair society for all. Through human rights principles, such as justice for all, participation, accountability, and the indivisibility of rights, engineers can begin to embed human rights considerations into the design, planning, implementation, and decision-making processes. Examples discussed in this paper and the *Issues at the Intersection of Engineering and Human Rights* symposium—ranging from fire safety systems to accessible public transit—illustrate how engineering may help address systemic problems, empower communities, and safeguard fundamental rights. By embracing a holistic and ethical approach, engineers can not only advance their profession but also contribute to the broader societal goal of upholding human dignity and fostering a sustainable future.

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