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WIP: Integrating Human Rights Frameworks and Reflective Learning into Engineering Senior Design

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Abstract

This paper explores the integration of human rights-based frameworks in a multidisciplinary senior design project at the University of Connecticut aimed at creating an affordable, modular wheelchair ramp using recycled materials. The project central to our analysis builds on the previous work carried out by other School of Mechanical, Aerospace, and Manufacturing Engineering (SOMAM) teams. The newest version of the project (i.e., 2024-2025) validates and expands upon previous efforts by involving students who are specializing in Human Rights and Sustainability (HRS). Given that this is the first time HRS students have participated in senior design, this paper explores the challenges and benefits of diverse team formation and collaboration across disciplines. We identify lessons learned from an instructor and student perspective. The paper emphasizes the teaching and learning processes, focusing on a combination of discovery methods that aim to afford students sufficient reflection time to enable them to learn from each other's disciplines. By carefully documenting students' and instructors' experiences at multiple points in the educational process (i.e., defining the project scope and goals, timeline, material testing, industry partner engagement, and prototyping), this paper reflects on the complex learning journey of students and the integration of human rights principles in engineering education. These insights offer valuable perspectives on how reflective learning and guided inquiry can shape effective, sustainable, and inclusive design solutions.

Introduction

Human Rights and Sustainability specialization equips students with the essential knowledge and skills necessary to analyze and address the complex intersection of technology, society, and the environment. As the broad field of engineering continues to evolve and reach to serve the public in a social manner [1], students use their engineering background to help shape communities, economies, and ecosystems while considering sustainable engineering practices and the respect for fundamental human rights as reflected in the Universal Declaration of Human Rights (UDHR). The curriculum of this specialization emphasizes an interdisciplinary approach with a strong engineering core, blending engineering principles that also touch upon environmental science, economics, political science, and social responsibility. Students explore a broad spectrum of challenges, such as climate change, resource depletion, social equity, and indigenous rights, learning to develop practical solutions that promote sustainability and resilience framed in relation to human rights norms, law, and principles.

This combination of learning paths culminated in a two-semester senior design project, where students integrated preventive, restorative, and proactive approaches to human rights into their engineering project. By applying the preventive approach, they designed solutions that avoid or mitigate adverse impacts on people and the environment. Utilizing the restorative approach, they developed strategies to remedy any harm that affects certain populations. In this case, considering the rights of persons with disabilities, the project centered on the design of an affordable wheelchair ramp, which was developed over two semesters. This project stemmed from two previous senior design efforts. In its third phase, it brought together engineering students from both the human rights specialization and SOMAM. This approach allowed them to critically analyze the previous reports done by other student teams while inviting for the first time a formal exploration of the impact of their design that could adapt to future accessibility situations and circumstances while promoting sustainable innovation practices and alignment with the Conventions on the Rights of Persons with Disabilities (CRPD).

Through the constant revision of their timeline and hands-on experiences, students in this capstone project considered the consequences of their decisions in short and long-term timeframes, the use of proper materials, and the choice of engineering solutions that aligned with the broader goals of equal access to public service [2], environmental protection, social justice, and economic inclusivity.

With the constant input and collaboration of industry experts associated with this capstone project, students gained the expertise in managing a project that covers core sustainable design practices and learned to integrate green technologies in this specific scenario. The team chose this project because they were interested in the potential role of human rights in the field of engineering, which aligns with a pro-ecological approach to environmental issues in general [3]. The guidance of their main advisor and assigned industry consultants brought the experience and insight from having worked in public agencies, private enterprises, and communities to craft a solution that would be prototyped in a context of constant reflective learning and prototyping.

Background

Human rights, in simple terms, are claims made by someone or someone else regarding something essential to human dignity, such as freedom from arbitrary detention or the ability to exercise the rights to work, housing and education without discrimination ([2]). The International Bill of Human Rights (IBHR) consists of three key documents that collectively establish fundamental human rights principles and protections: 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). The Convention on the Rights of Persons with Disabilities (CRPD) builds on the IBHR principles to address the specific rights and protections of persons with disabilities; it was developed jointly with persons in the disability community.

One of the most distinctive characteristics of the CRPD is thus its shift to a comprehensive approach to disabilities, establishing disability as a social construct, where disability results from the interaction between an impairment and the built environment. It is an environment where engineers have a particular influence. The CRPD further establishes a human rights-based model of disability, distinct from the so-called medical model (in which disability is seen as an individual deficit that needs to be fixed or adapted to inaccessible environments). In the human rights-based model, on the other hand, the focus is on fixing the system so persons with disabilities face fewer excluding environments—both attitudinal and physical.

In the case of the senior design project, the mentioned wheelchair ramp project represents an ambitious project that is led by three industry experts and a main advisor to create an accessible, cost-effective, and sustainable solution for people with mobility challenges as a remedial approach to address the exclusion of persons with disabilities from activities of everyday life. This project was initially brought into the scope of completion as a senior design project led exclusively by mechanical engineering students. Building upon the foundation laid by these two previous teams, the goal was expanded on its third edition, and it aimed to first validate all the engineering calculations and design. Secondly, it aimed to bring new ideas within a multidisciplinary setting, incorporating other metrics in the engineering process relative to environmental sustainability, usability, setup and transportation to the site, or accessibility. In this framework, the team of students was exposed in roles that allowed them to analyze the ramifications of new fabrication methods and use of materials, and grapple with the ramifications of their choices, positive or negative [4]. From a practical solution, our team of students sought to reduce manufacturing costs by narrowing down the previous choices of recycled materials, while providing a modular design for ease of assembly and repair and knowing that it would be both functional and visually appealing.

This edition revised the specifications outlined in the Americans with Disabilities Act (ADA) for wheelchair accessibility, concepts related to the CRPD, and recalculated the structural integrity of the last two editions of the preliminary ramp designs, checked the compliance with the necessary standards for slope, width, and weight-bearing capacity under multiple weather conditions and use, and found ways to produce the final design at a reasonable cost.

The inclusion of a student with the specialization of human rights widened the project's scope, ensuring that the design would not only meet technical requirements but also would align with values of social responsibility and environmental sustainability. A critical goal of the new team was to seek ways to make the ramp affordable, particularly within a set of users coming from low-income backgrounds, or from those who struggle to find the resources necessary to afford such essential accessibility features.

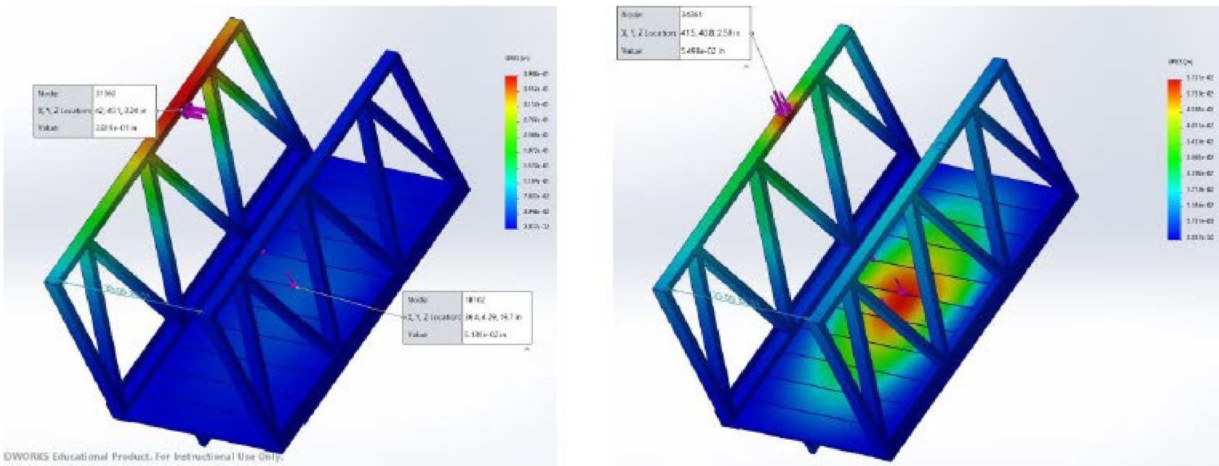
Senior Design Class

In the context of using reflective practice techniques, this Senior Design class was constructed around weekly meetings with the clients, allowing students to set and maintain high order goals for the entire duration of the project, and the subsequent adherence to smaller weekly goals. This structured process of goal identification let them achieve their objectives, a valuable learning activity due to its reflective nature [5]. Additionally, the students were asked to follow a monthly report on their progress following the Learning Outcomes set up in the course description, and in alignment with ABET accreditation standards. That encouraged a more honest reflection on their goal-setting approaches, which were set in place with the declaration of a timeline of actions in a Gantt chart, which they were asked to bring along at each client meeting. This created a deliberate action towards setting their ultimate goals for the class.

Material selection became a focal point of the project during the first semester. While the previous teams had considered a short range of materials, the third edition team, under the advice of their three industry experts, noted that the choice of making a ramp that would be made of recycled materials would have to be narrowed down to two significant materials, one recycled plastic material for the main ramp planks and platforms, and one metallic material for the structural framework.

The team realized that their choice of polyethylene terephthalate (PET-1), a common type of plastic that is widely recycled, offered a sustainable alternative to traditional materials and that their choice of aluminum offered a great strength-to-weight ratio and long-lasting properties. This choice not only provided a solution with a reduced environmental impact but also contributed to keeping costs down. However, sourcing the appropriate recycled PET-1 material with the correct thickness and specifications posed a significant challenge for the team, as the industry contacts proved difficult to obtain in the desired form for manufacturing.

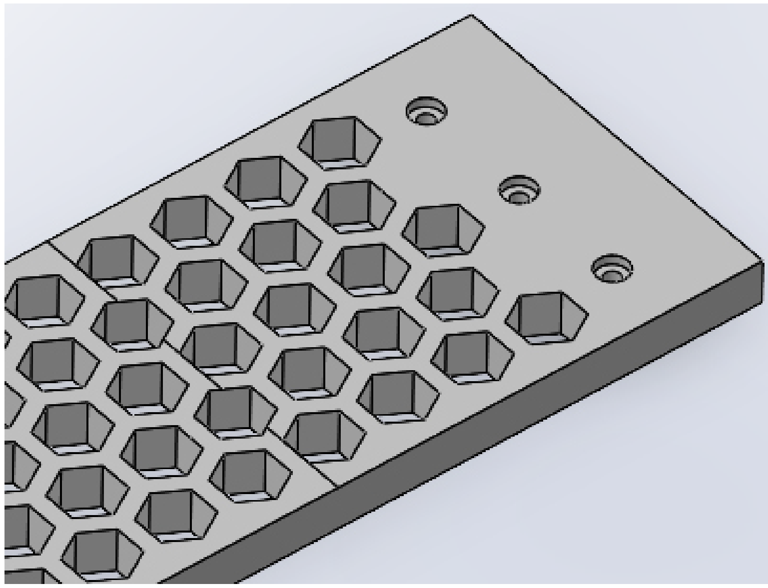
To address the structural integrity of the design, the team utilized computer-aided design (CAD) software and structural simulations. The team spent considerable time refining the existing CAD models from the two previous and added additional features prior to performing a batch of Finite Element Analysis (FEA) calculations to evaluate the ramp's ability to support the weight of wheelchair users. The initial findings of these structural simulations showed that the PET-1 material was capable of safely supporting the wheelchair loads; however, the simulations revealed a significant issue: the handrails, the footings, and other components of the ramp were deflecting beyond safety limits or were not strong enough, and the team had to revisit their design and implement reinforcements to ensure an equitable use under the principles of universal design [6] and basic safety guidelines, as seen in the FEA examples[1].



Finite Element Analysis on handrails, with X direction isolation and Y direction isolation (1)

As the team moved forward with the design, they had to reconsider their manufacturing methods. The challenges in sourcing the recycled PET-1 material, combined with the need for precise thickness specifications, led the team to reevaluate their predictions for both cost and manufacturability. The team recognized that to ensure the ramp was both affordable and practical, they needed to narrow down their choice of manufacturing processes, opting for

panels that carefully balanced carrying weight limits for a reasonable setup and the constraints of manufacturing, as seen in the proposed removable tile design[2].



Design proposal of removable tiles for the ramp and landings to ameliorate snow loads (2)

The team aimed to design a product that would not only be cost-effective but would be easy to repair, offering users a practical solution that could be easily transported to the construction site. In their analysis, the team also considered broader implications of their design, such as the impact on the users under extreme weight conditions due to external weather circumstances, photochemical aging, possible cracking or corrosion, and the shifting of the soil under the ramp. Additionally, the advisors guided the human rights student on issues such as considering daily uses and equitable use guidelines like safety concerns, design appearances, and avoiding stigmatizing users.

Ultimately, the team worked heavily on solving the major engineering challenges, and the wheelchair ramp design fell behind on fully applying sustainable principles beyond choosing the main construction materials and the design of the main planks. The team made progress in implementing a CAD prototype ready for 3D printing in scale to convince local lawmakers to create a physical proof of concept. This traveling model would eventually be used to gather momentum to fund the construction of a ramp prototype that could be used for veteran housing.

Lessons Learned

A Focus on Accessibility and Project Challenges

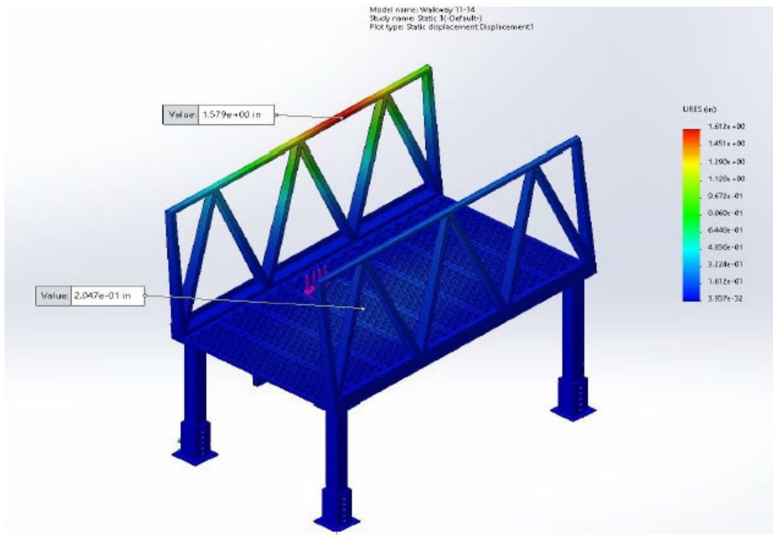
Throughout the course of the project, the team confronted challenges that tested both their technical capabilities and their commitment to accessibility. While their primary focus remained on offering a solution that could be built with the right materials, the task of keeping fresh in their minds the goal of offering accessibility for all users needed constant reminding, such as keeping the samp angle constant with the correct landing distances, working with hand rests at the right height or making sure that the modular elements connected with a minimum change in height when transitioning from space to space. The advisors and professionals also made sure that the work aligned with the vision centered heavily on selecting recycled materials and giving a solution to the pressing need for persons with disabilities. These meetings also revealed important lessons and insights that shaped our approach and strategy moving forward.

Lesson 1: Validating Previous Designs

One of the most valuable lessons the team learned was the importance of thoroughly validating previous designs. During the early phases of the project, the team assumed that earlier designs were reliable and accurate. However, they realized that mistakes are often present in previous iterations, particularly when designs are inherited from other teams. Errors in these designs, whether stemming from miscalculations, overlooked assumptions, or a lack of effective communication, can critically compromise the integrity of the final product. Recognizing this, they made it a priority to validate all preceding work and improve collaboration to minimize such risks. This ensured that any issues were caught and rectified before proceeding further. This step, while time-consuming, helped them advance solidly in their timeline.

Lesson 2: Incorporating Human Rights from the Start

Another key lesson revolved around the importance of integrating human rights factors into the design process from the very beginning, especially considering that most of the team members came from SOMAM. This early involvement of our students specializing in Human Rights and Sustainability ensured that the design process considered the needs and perspectives of marginalized communities, and the value of incorporating human rights principles in engineering education [7]. The team learned that failing to incorporate human factors early created gaps that could later be difficult to address. This brought up the discussion of the cost involved in retrofitting infrastructure when a proactive, inclusive design is not considered. Engaging with human rights principles from the beginning of the design opened discussions in class about the legal consequences of not following directives Human Rights Due Diligence (HRDD) as a defense mechanism against liability, or the need of remediation. Students understood the importance of the creating of this ramp, as a tool to cover an existing liability gap in populations of need or marginalized communities and highlighted the actions that construction companies might take to favor more inclusive designs, precisely to avoid costly retrofits [8]. Other important topics emerged, such as keeping a functional design under the maximum weight use of a person in a wheelchair and a companion during a maximum weight load in a snowed-in situation. This scenario informed the need to reconsider the truss design. This, as well as other examples on reach and use, highlighted the fact that incorporating human rights considerations from the early stages needed to be a priority and not an afterthought3. Key articles that emerged in this discussion include UDHR's Article 1 ("All human beings are born free and equal in dignity and rights"), Article 25 ("Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family"), and Article 13 ("Everyone has the right to freedom of movement and residence within the borders of each state"). Similarly, CRPD's Article 9 (which explicitly addresses that persons with disabilities should have access to facilities, transportation, and public services on an equal basis with others) and Article 20 (which relates to personal mobility that is accessible and affordable) are also relevant.



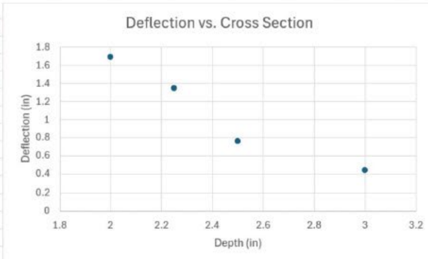
Optimization of truss and handrail design to increase efficiency and loads (3)

Therefore, the student in charge of human rights worked on reminding the students in mechanical engineering that these were also important expectations and that these should be considered throughout the project to maintain the ethical integrity of our work.

Lesson 3: The Role of Finite Element Analysis and review of material properties

Finite Element Analysis (FEA) and a careful review of material properties proved to be both an invaluable source of information as well as grounds for potential delays. Students discovered that FEA is essential for validating structural and material choices but also discovered that its complexity can sometimes result in delays that affect the project's timeline. However, the accuracy and reliability of FEA ensured that the final product met design criteria despite the considerable time investment. This insight reinforced the idea that while timely progress is important, it should not come at the expense of making a design not rigorously tested or validated, such as the example shown on the deflection of PET-1 once and UV coatings available[4].

Width (in)	Depth (in)	Weight (lb)	Deflection (in)
1	2	42.32	1.692
1.125	2.25	53.23	1.342
1.25	2.5	65.3	0.759
1.5	3	92.84	0.435



COLORMATRIX™ ULTIMATE™ UV TECHNICAL AND REGULATORY INFORMATION

	ColorMatrix™ Ultimate™ UV390	ColorMatrix™ Ultimate™ UV390R
UV Protection	Up to 390 nm	Up to 390 nm
User	Convertor	Convertor
Color	Colorless	Colorless
Recycling Accreditation	EPBP APR	EPBP* APR*
Lightweighting	✘	✔
Productivity Saving	✘	✔

Thermal coatings for PET-1 and its recyclability effect *(4)*

Lesson 4: Material Sourcing Challenges

Another persistent challenge was sourcing the correct materials for construction and for prototyping. Students struggled to find choices of materials that could be available in a bevy of options, and while they initially considered a hybrid decision matrix to decide on them [9], the team quickly found that a synthetical approach matrix for the material selection was the most practical after hearing industry experts, when considered the limited options of availability, cost, and suitability for specific applications for PET-1 Time delays in procuring PET-1 samples, forced the team to adapt and look for alternative solutions for the planning of producing physical prototypes of connectors and hardware choices. This underscored the need for careful planning and a proactive approach to material sourcing from the early stages of the project.

Lesson 5: The Struggles of Maintaining a Budget

One of the most challenging aspects of the project was keeping the budget within the initial estimates after the material choices were made. Students realized that engineering projects often require adjustments as new challenges arise, and despite their best efforts to manage costs efficiently, the fluctuating cost of PET-1 and the use of proper coatings made it difficult to keep the original budget and project goals intact. This experience taught the team the importance of budgeting flexibly and with foresight and tracking major material costs on a regular basis to prevent overspending. As novice engineers, students tend to reflect only after mistakes are made, while engineers with more experience reflect on a continuous basis [10]. This was evident in students' struggles to maintain their project budget. Despite efforts to manage costs, fluctuating PET-1 prices and available plastic coating forced them to account for the accrual of more flexible budgeting and foresight to avoid overspending during their cost tracking phase. In the end of their project, a more continuous reflection helped anticipate and address these challenges more effectively.

Lesson 6: The Unknowns in Engineering Project

Perhaps the most significant lesson the students learned was the realization that "you do not know what you do not know." Engineering projects are inherently complex, and there are always unknowns that surface as the project progresses. We often found ourselves encountering challenges that were difficult to predict or prepare for, and in those instances, we must adapt quickly and contextualize the work for improvement, knowing that there are different methods to achieve this in a classroom setting. One of the most productive conversations occurred when participants saw improvement strategies as interconnected and inseparable, and by acknowledging the interactional nature of contextualization, they focused on enhancing design processes and creating positive social impact [11]. This lesson reinforced the importance of maintaining a mindset that is open to learning and problem-solving and showed a significant improvement in the quality and sophistication of her responses by the beginning of the second semester. These results align with the reflective learning outcomes practices in engineering, where some students experience a shift in focus from merely providing solutions to considering evaluation and ethics [10]. These evaluations led to question new rising challenges, and that the ability to respond to them is what eventually determines the success of any project.

Preliminary Conclusion

While the project had another semester till completion, it presented numerous challenges and was already a valuable learning experience. The multiyear nature of the project, which focused solely on mechanical engineering issues till this last edition, introduced a unique perspective, and required sustained effort and adaptability. This complexity was further compounded by the need to rethink designs from the outset, incorporating a reflective approach on the entire process, and in particular to the human rights principles in ways that fundamentally challenged conventional engineering assumptions. Balancing these transformative priorities with traditional engineering roles—such as maintaining a lower budget, navigating materials sourcing, and employing advanced techniques like finite element analysis— added additional layers of uncertainty and complexity.

Each lesson learned, from validating designs to balancing budget constraints, improved our understanding of the complexities of engineering design. By committing to our core goal of improving accessibility for all, we made meaningful progress, even in the face of uncertainty. This experience equipped the students with the knowledge and skills to approach future projects with a more holistic, informed, and principled perspective.

References

[1] S. Beder, "Beyond technicalities: Expanding engineering thinking," *Journal of Professional Issues in Engineering Education and Practice*, vol. 125, no. 1, pp. 12–18, Jan. 1999, doi: 10.1061/(ASCE)1052-3928(1999)125:1(12. Available: https://doi.org/10.1061/(ASCE)1052-3928(1999)125:1(12)

[2] N. U. Nations, "Convention on the Rights of Persons with Disabilities," *Jahrbuch Für Wissenschaft Und Ethik*, vol. 14, no. 1, pp. 203–226, Dec. 2009, doi: 10.1515/9783110208856.203. Available: https://doi.org/10.1515/9783110208856.203

[3] Lee, M., Chacon-Hurtado, D., Hertel, S., & Fenn, S. (2024). Engineering Education in Human Rights and Sustainability: Exploring Students' Motivations and the Learning Outcomes from an Undergraduate Class at the University of Connecticut. *2024 ASEE Annual Conference & Exposition*. https://doi.org/10.18260/1-2--47279

[4] Chacón-Hurtado, D., Kazerounian, K., Hertel, S., Mellor, J., Barry, J. J., & Ravindran, T. (2024). *Engineering for human rights: The theory and practice of a human rights-*

based approach to engineering. *Science, Technology, & Human Values, 49*(4), 898–934. https://doi.org/10.1177/01622439231211112

[5] Goncher, A. (2018). Utilizing Reflective Practice to Develop Agency in Goal Setting and Achievement in Workplace Learning Environments. *2018 ASEE Annual Conference & Exposition*. https://doi.org/10.18260/1-2--31219

[6] "The 7 Principles - Centre for Excellence in Universal Design," *Centre for Excellence in Universal Design*. Available: https://universaldesign.ie/about-universal-design/the-7-principles

[7] Reuter, T. K. (2019). Human rights and the city: Including marginalized communities in urban development and smart cities. *Journal of Human Rights*, *18*(4), 382–402. https://doi.org/10.1080/14754835.2019.1629887

[8] Teaching business and human rights. (2023). In *Edward Elgar Publishing eBooks*. https://doi.org/10.4337/9781802201130

[9] H. Zhang, Y. Peng, G. Tian, D. Wang, and P. Xie, "Green material selection for sustainability: A hybrid MCDM approach," *PLoS ONE*, vol. 12, no. 5, p. e0177578, May 2017, doi: 10.1371/journal.pone.0177578. Available: https://doi.org/10.1371/journal.pone.0177578

[10] Campbell, R. C., Reible, D. D., Taraban, R., & Kim, J. (2018). Fostering Reflective Engineers : Outcomes of an Arts- and Humanities-Infused Graduate Course. *2021 World Engineering Education Forum/Global Engineering Deans Council (WEEF/GEDC)*, 1–6. https://doi.org/10.1109/weef-gedc.2018.8629714

[11] Kleine, M. S., Zacharias, K., & Ozkan, D. (2023). Contextualization in engineering education: A scoping literature review. *Journal of Engineering Education*, *113*(4), 894–918. https://doi.org/10.1002/jee.20570