STEM Education's Misalignment to Proactive Accessible Design: Policy Recommendations for Realignment

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Abstract

The Engineering Design Process (EDP) continues as the primary means for teaching engineering design to the future engineering workforce. Embedded in this process are pre-qualifiers for design success that help to determine the final designed solution. These pre-qualifiers have effectively "funneled out" the needs of marginalized populations, particularly those with disabilities. As a result, the EDP has excluded those with disabilities from design decisions in a product's infancy stage. As the EDP is central to the teaching and standardization of engineering design, changes need to be made to the teaching of this process to encourage equitable and accessible design for persons with disabilities. This chapter reflects on STEM education's current misalignment in teaching design for accessibility, sustainability, and equitability. We show that the currently taught design standards do not align with the UN's Disability Inclusion Strategy, which hinders the accessibility of future designed products. We put forward a set of recommendations on how to promote proactive accessible design, aimed at policy makers, research funders, STEM educators, and research institutions. These stakeholders must steer design consideration priorities, including by altering its teachings to not only include, but prioritize the needs of the disabled community.

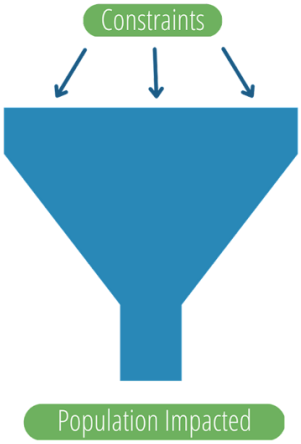
In 2018, the Executive Office of the Secretary-General vocalized the urgent need for the United Nations to improve its performance with regards to disability inclusion in order to achieve the 2030 Agenda for Sustainable Development [1]. An institutional review was conducted on the rights of persons with disabilities in response to this call, resulting in the development of the United Nations Disability Inclusion Strategy. The strategy explores the meaning of disability inclusion through a policy and accountability framework to ensure that the United Nations moves towards sustainable and transformative disability inclusion [1].

The UN Disability Inclusion Strategy [1] defines disability inclusion as, *"The meaningful participation of persons with disabilities in all their diversity, the promotion of their rights and the consideration of disability-related perspectives."* Although this strategy initiates an important first step to the inclusion of persons with disabilities (PWD), missing from this plan is specific accountability towards accessible design, which is central for equitable participation of persons with disabilities. Science, Technology, Engineering, and Math (STEM) education as a discipline is inextricably linked to policy and governance [2, 3]. Specific to engineering, the Engineering Design Process (EDP) is a way in which decision makers decide who is included and disincluded in the design of a system [4]. This process is central to the teaching and standardization of engineering design. Thus, changes need to be made to the teaching of EDP to encourage equitable and accessible design for persons with disabilities.

The funneling out of engineering design

Starting with an overly broad scope in the EDP allows for the unintentional weeding out of certain populations from a design. Many times, the needs of marginalized communities are "funneled out," resulting in their needs being left out or forgotten.

Figure 1. The "funneling out" of marginalized populations in the currently used EDP



Narrowing the scope beginning of the EDP allows engineers to focus on a specific subset of a population. Following Universal Design [5], narrowing the scope to the needs of specific marginalized communities reverses the funnel to include the needs of all stakeholders.

Figure 2. "Funneling in" marginalized populations into the EDP

Proactive accessible design begins in the classroom

Recommendation 1: Redefining stakeholders and needs assessment

Engineering design standards are rules and regulations for the designing, testing, analysis, and manufacturing of products [6]. No universal recommendations have been made thus far for inclusion of those with disabilities in the EDP, or specific to the STEM education realm. Such recommendations are important as the EDP influences nearly every engineered product. Students with disabilities (SWD) must be at the forefront of these accessibility conversations in order to help prevent the "funneling out" of disabled populations in engineered products.

Proactive accessible design begins by redefining who is included and disincluded in product design decisions. The EDP currently identifies who a design is for during the beginning three stages of the design process. These stages are also when product constraints (e.g., time, money, and materials) and success criteria are determined to select the product's designed solution. Many times, PWDs are effectively "funneled out" of design decisions due to their needs being identified as constraints, as accessible design can be admittingly more resource intensive. When PWDs are not identified as end-users during the problem identification, their needs are often disregarded, and products are *designed against them*. To *design for disabilities*, we must change the current structure of the EDP to include disabled and other historically marginalized populations from the beginning stages of the design process. The EDP must also balance constraints with the needs of PWDs during solution selection. If our goal is to reach goals outlined by the UN Disability Inclusion Strategy, we must treat the needs of PWDs as unyielding requirements in our product success criteria.

Recommendation 2: Teaching accessible design throughout a four-year curriculum

Common models for engineering curricula require students to enroll in design courses during their first or second year of undergraduate studies. In the larger context, this means that most students are usually taught about design methods only once throughout a 4-year curriculum, often in an ad-hoc manner, before they ever reach their capstone experience.

The need to develop an empathy-led mindset leading to more inclusive design means that students would benefit from curricula that integrate design courses throughout their degree progress. Scaffolding concepts of inclusive design throughout the curriculum, and across topics, can aid students learn how to apply these concepts to the creation of solutions to problems at different levels. Such an approach would support the students' long-term learning of the concepts, while also helping them to understand how technical and social concepts can coalesce as part of their engineering identity.

Accountability is needed to promote system-wide changes to engineering design standards

Recommendation 3: System-wide policies and practices on accessible design teaching

With presence in 40 countries, ABET is the current global authority dedicated to the accreditation of engineering programs, and has the potential to become a key contributor to the proliferation of accessible design practices around the world. As it currently stands, ABET's criteria for Student Outcomes includes students ability to apply the EDP in order to produce "solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors" [6] Although their current accreditation standards mention the need for programs to have "engineering design" credits coupled with a culminating design experience as part of their core curriculum, there is no clear criteria that measures how these courses or experiences are teaching students how to produce designs that will indeed meet the needs stated in their Student Outcomes. Instead, the weight of other accreditation considerations often leads institutions to focus their educational efforts on the technical aspects of the EDP, eventually causing students to devalue the importance of social-technical aspects leading to inclusive design [7 - 9].

By providing clear criteria for the evaluation of the quality of inclusive engineering design courses in the engineering curriculum, ABET could set standards that would assist institutions in the evaluation of their efforts to teach inclusive design. In the long run, such changes will help educate new generations of engineers that understand the importance of inclusive design and put it into practice along their careers.

Recommendation 4: Institutional policies and practices on accessible design teaching

While it is vital that the movement for inclusive design teaching be supported by external policies, such as those inferred by the ABET accreditation standards, it is just as key that institutions of higher education create and enact policies within schools and departments that can aid the professoriate in its implementation and further sustainability. In saying this, we recognize engineering is taught through many diverse institution models that vary by research and teaching focus, where the ability to change current curricula and courses can vary greatly [10].

As such, we would exhort institutional leaders to advocate for institutional policies and practices that fit their mission and culture, while enabling their faculty to integrate tenets of inclusive design into their current courses. For example**,** in institutions where research is prioritized this could take the form of including incentives in new faculty contracts for the integration of inclusive design in the courses assigned to them, perhaps creating evaluation mechanisms that may consider this as part of their work towards tenure while alleviating their research publication load. Other such practices may be the development of workshops for faculty where they may learn how to prepare and adapt lesson plans for inclusive design, or the creation of a task force dedicated to the creation or modification of new and existing courses. Whatever the model, institutional policies and practices are key to providing the systematic approach that will decisively contribute to how new engineers learn and apply design processes.

Recommendation 5: Redefining who drives accessibility conversations

Finally, we invite institutions and accreditation organizations to bring the perspectives of PWDs into their plans for the implementation and evaluation of accessible and inclusive design practices. As primary stakeholders in these processes, their point of view can primarily serve as a touchstone for the impact that these policies will signify for the student body. For this purpose, structured empathy-based design methods, such as Design Thinking [11], have been successfully used in the past to gather perspectives of SWD in higher education institutions. Thus, such methods may be applied to gather their points of view as to how policies and practices created by institutions and organizations are indeed contributing to foster, not only the creation of accessible spaces, but also a meaningful inclusive design culture in schools of engineering.

Conclusions

This policy brief argues the urgent need for reassessment of the EDP and its teachings to future engineers. It emphasizes curriculum and policy areas that could form the basis of engineering design standards fit for an equitably designed future. Creating an enabling environment for accessible design to positively impact the products for, communities of, and lives of those with disabilities should be a fundamental principle of future engineering policy if it is to effectively support the SDGs.

Many engineering programs and companies are developing specific strategies to support the accessible and equitable design of future products; however, they are in their infancy. The evaluative impact of these strategies should be a policy priority to establish what works and of equal importance, what does not. Through such support, accessible design standards and teachings can be developed to support those with disabilities and the future generations of engineers. Cooperation, knowledge sharing, consensus building, and regular discussions amongst the disabled community, policy, educational, and industry leaders is critical to ensure that future engineered products are *designed for everyone*.

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