Mechanical engineers and their relationship with sustainability

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree Bachelor

of Science, School of Engineering

Adam Centanni

Spring 2024

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Advisor

Pedro A. P. Francisco, Department of Engineering and Society

STS Research Paper

Introduction

The definition of sustainability, per the United Nations, states that humanity must meet the needs of the present without compromising the ability of future generations to meet their own needs (Nations, n.d.). As humankind continues to use the finite resources available for production, it is critical that the processes themselves are modified to include sustainable thinking. If unsustainable processes continue to be used, then the finite resources will diminish future generation's ability to provide for themselves.

Mechanical engineers are responsible for the design and analysis of systems that exist within a wide spectrum of applications. For example, mechanical engineers can be responsible for studying systems at a molecular level or for managing heating and ventilation in large buildings. The breadth of mechanical engineers' work therefore is a nontrivial aspect of the profession in the context of this paper, as their ability to affect a plethora of processes is inherent in their work. With their wide range of influence over processes of production, they become critical components to reinforce sustainable thinking in design and production processes. In order to preserve not only current generations' livelihood, but also future ones, mechanical engineers must take a critical look at what processes are unsustainable, and think about how engineering knowledge can be implemented to increase sustainability within such designs.

However, while the aforementioned common definition of sustainability provides a concise understanding, it fails to capture the complexity and challenges that are a part of sustainability. Depending on the profession or discipline, what is considered to be sustainable differs. Therefore, when working in multidisciplinary teams, an unclear understanding of what sustainability means can inhibit sustainable thinking being implemented in designs. This paper

not only seeks to understand what the current role is of mechanical engineers and sustainability implementation, but also seeks to develop a broader understanding of what sustainability means. By looking at different disciplines and asking what their definitions of sustainability are, an understanding of sustainability will be achieved, and can be used to highlight what the mechanical engineering profession does well, and where some areas of improvement are.

Background / Theoretical Framework

Mechanical engineers complete work in a wide array of disciplines. Using a broad foundation of physical principles, mechanical engineers use formulas to create models to analyze and understand physical phenomena. It is difficult to be specific when talking about what mechanical engineers do because, even within the same discipline, mechanical engineers may be tasked with different problems. The wide range of work they complete places mechanical engineers in a unique position. If they are proponents of sustainable design, this will help intensify the conversation of sustainability in a variety of areas. As people actively responsible for the design process, mechanical engineers make decisions that can be thought about within sustainable thinking. It is therefore critical that mechanical engineers have a solid understanding of sustainability, as their ability to influence a wide range of applications can make a difference as to how emphasized sustainability is during the design process.

Currently, sustainability typically means lowering costs and increasing profits in the space of mechanical engineering (Brown, 2012). This concept of sustainability fails to consider the other aspects of sustainability, such as the environmental and social impacts. Furthermore, if the sustainability considerations mechanical engineers make only focus on the lowering of costs and increasing of profits, then the processes that a mechanical engineer is involved in will be less likely to consider the environmental and social obligations designs have for the public.

This leads to two main issues with the relationship mechanical engineers have with sustainability: an unclear understanding of what sustainability means, and a lackluster definition of sustainability for mechanical engineers. Within the workplace, an unclear definition of sustainability may cause a mechanical engineer to consider certain aspects of their design, and leave out critical considerations. For example, the lowering of costs typically is emphasized in mechanical engineers' work (Brown, 2012). This is an issue because if mechanical engineers are not asked to consider sustainable design in their practice, with a complete definition as to what sustainability entails, their designs will continue to propagate unsustainable practices. Therefore, a robust, clear definition of sustainability must be developed, one that highlights what mechanical engineers have done well and adds to what they can consider. Mechanical engineers have the ability to maximize their output for the input provided, however, moving forward there should be an increased emphasis on what it means to design socially and environmentally sustainable systems within the mechanical engineering practice.

This paper will conduct a literature review, of examples of sustainability within and outside of mechanical engineering in order to understand what sustainability is considered today. Looking at different disciplines definitions of sustainability, the literature review will be able to highlight some of the differences between those definitions and the ones within the mechanical engineering practice. The analysis of this difference is critical, as what mechanical engineers have not been considering can be added to their definition of sustainability, helping to ensure that their work is well informed and properly takes care of the complexity of sustainable design.
To help mitigate the barrier of implementing sustainable design, this literature review will aim to highlight the complexities of sustainability and include some aspects which are important in its consideration. Once there is a clear articulation of sustainability, mechanical engineers will be

able to look at such a definition, one that considers sustainability beyond optimization, and can design with this thinking in mind.

If mechanical engineers do not consider a more robust definition of sustainability, their wide influence in a multitude of applications will fail to be a voice for sustainable design. Considering the finite resources on Earth and the plethora of unsustainable practices that exist today, there must be professionals who actively work to preserve and protect the resources and livelihood of the public. Without professionals considering sustainability who are within influential positions, unsustainable practices will be able to persist and continue to harm the environment and society.

Methodology

In order to understand the relationship between mechanical engineers and sustainability, an understanding will be developed as to what mechanical engineers have considered sustainable practice and design both in the past and present. By compiling information as to what mechanical engineers have considered sustainable practice in the past, and contrasting that with the information on what they consider to be sustainable today, the ideas of sustainability can be compared to understand how the definition has changed, areas of improvement, and weaknesses.

With the interpretive flexibility of the concept of sustainability, there are consequently many ideas as to what it may mean, beyond the mechanical engineering discipline. The scope of this study is not to develop a holistic understanding of sustainability by compiling many different professions' perspectives. It will, however, seek to develop an array of perspectives, especially those that contrast with the mechanical engineering definition the most, in order to challenge the idea of sustainability that mechanical engineers typically associate with their work.

The information concerning ideas of sustainability, within mechanical engineering and outside it, will be obtained through a literature review of relevant academic journals and articles. Furthermore, sustainable design and technologies will be understood within the Social Construction of Technology (SCOT) framework, as SCOT asserts how technology is not a passive entity. As the designs and practice of mechanical engineers affects people and the environment, their solutions are non-passive entities, and therefore must be understood as actors that can positively or negatively affect society, the environment, and the economy.

Literature Review

Given that Mechanical Engineers have the unique ability to use their knowledge of mechanical systems to fabricate designs in real life, there is an associated responsibility of making sure what is fabricated is sustainable. Sustainable design is critical to preserving the planet and its resources, and by understanding how Mechanical Engineers incorporate sustainability into their designs, it is possible to see how they can contribute to mitigating the climate crisis. Within the SCOT framework, it is understood that the technology mechanical engineers develop is not a passive entity. As the technologies these engineers develop use natural resources and affect the environment, it is clear that the systems they create are not neutral entities that have no effect on the environment, society, and economy.

Identifying the barriers to sustainability implementation will help identify ways Mechanical Engineers can help create solutions to mitigate the climate crisis. In order to identify the barriers to sustainability implementation, a historical timeline is developed to understand where the relationship has been, and in what ways Mechanical Engineers have considered sustainability, and a critical perspective will be discussed, covering the modern definitions of

sustainability and current examples of sustainable, or lack thereof, work Mechanical Engineers complete today.

Within a critical lens, one of the main issues in understanding sustainability is that it has been defined in many ways by many groups of people (Fisher et al., 2021). In the article written by Fisher et al, the authors note that sustainable development can consider not only our relationship with natural resources, but also with the "intrinsic value of nature on mental health and well-being." As the paper was written in 2021, this is a relatively modern outlook on what sustainability can mean, noting the addition of mental health and well-being. Furthermore, Fisher et al argue that sustainable development includes ideas that enable people to self-actualize, or feel like they can fulfill their potential. This paper provides insight into what social sustainability can mean, as the authors highlight the importance of mental health and self-actualization, not as a minor part of the entire scheme, but rather a critical feature of sustainable development itself.

Furthermore, many people have completed work creating frameworks to revolutionize how sustainability is approached, and scholarly articles concerning such work are studied in order to develop this lens. In order to address the complexities of the climate crisis, new solutions must be produced. For example, sustainability education is being implemented at higher education institutions, and the design of sustainability curriculum is studied in order to see if they improve students' outcomes (Kishita et al., 2018). Beyond educational institutions, there are examples of frameworks of sustainability outlines that describe a timeline of goals in order to achieve net zero emissions in the particular region of Texas in the United States (Webber, 2023). By studying how sustainability is taught, and looking at modern examples of its implementation, it can be determined how effective sustainable solutions are in delivering their goals and if there are weaknesses in sustainability education/implementation. Within the critical lens, the barriers

to sustainable design, especially societal barriers are considered. The issues of seeking increased profits and implementation of economic policies antithetical to sustainable design cause sustainability applications' realization to be slowed down (van der Leeuw et al., 2012).

Within the historical perspective, the definitions of sustainability defined in Mechanical Engineering itself differ, from understanding sustainability as a social concept (Johnson, 2022), to understanding sustainability as a means to lower cost and increase profit (Brown, 2012). Beyond the Mechanical Engineering space, there is variation in the sustainability definition among higher education institutions at the Bachelor level (Segalàs et al., 2009). Concerning the mechanical engineering profession, it is noted by Brown that regulatory requirements and industry organizations (such as the ASME and ISPE) are the main facilitators of more sustainable design practice (Brown, 2011). Furthermore, in another article by Brown, respondents to the survey stated that they would prioritize sustainable design practice if they are cost-saving, increase throughput, cut costs, and do not inhibit existing production. Therefore, iIt can be seen that a part of mechanical engineers' understanding of sustainability is dependent on optimizing designs for greater economic output, rather than analyzing products' life cycles, which through their energy savings, are able to make up for the cost associated with the sustainable design changes (Brown, 2011).

Discussion

The changing conditions of the climate crisis require the understanding of sustainability to evolve with it, and by seeing what has been considered sustainability, new areas can be identified and added to the definition in order to properly consider new aspects in sustainable design.

Within SCOT, the technologies made by mechanical engineers are not passive entities. In the effort to reduce cost and increase throughput, changes may be made which can improve the process, but be unsustainable. For example, Brown notes that moving production overseas helps organizations deal with fewer regulations, which can lead to unregulated unsustainable processes (Brown, 2011). While the mechanical engineering sustainable design practice focuses on optimization, the design practice can change to include energy savings over a long period of time in the optimization analysis.

Within the definitions of sustainability identified outside the mechanical engineering space, there is a greater exploration of social sustainability, and how designs can include decisions based on human well-being and mental health. Furthermore, there is notable overlap among spaces inside and outside mechanical engineering for their reliance on institutions to educate people about sustainability. Whether it be the higher education institutions teaching new engineering students, or industry organizations providing a clear regulatory understanding, it is important to have these institutions maintain sustainable thinking and education as a priority in their platform.

Conclusion

The mechanical engineering definition of sustainability considers how to optimize and maximize the output of systems. Over time, mechanical engineers have been able to reduce cost and increase output, leading to greater economic gain. However, in pursuit of this optimization, some design decisions have been unsustainable in the process, and with the current climate crisis and finite amount of resources available, continuing these unsustainable practices will lead to future generations not being able to provide for themselves. From other disciplines, ideas of

sustainability being associated with mental health and well-being can be added to the mechanical engineering design thinking in order to consider how technologies may affect people and the longer term effects. Furthermore, it is critical that institutions work on developing and educating their constituents as to the many areas sustainability covers.

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