The Challenges of Engineering Education, Engineering Practice, Code of Ethics, and Social Justice

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Abstract

During the ASEE Annual Conference in the summer of 2019, the Technological and Engineering Literacy and Philosophy of Engineering (TELPhE) Division voted, with the suggestion of our distinguished colleague Professor Alan Cheville, to include social justice as one of the key focuses of the Division. Since then, some of the members of the division have been working on different perspectives and dimensions of that suggestion. This paper provides observations, discussions, and perspectives on some of the challenges that we are facing in engineering practice and engineering education, as well as the technological literacy program regarding the inclusion of social justice.

When seeking avenues and possibilities of such inclusion, it is important to have a division wide discussion to gain a deeper understanding of the role and position of social justice in engineering practice, technological literacy, and in particular, engineering and technological literacy education. As a new generation of engineers and technologists are using, creating, sharing, and expanding the dominance of various technological artifacts in our daily lives, and in an ever changing, interconnected global community, it is of utmost importance for engineering educators to focus on educating the future generation with the right perspectives and understanding of the role of social justice and the danger of ignoring it in our daily lives and designs.

Introduction

For the last several decades it seems that the main focus in education has been almost exclusively on STEM initiatives. Particularly in the U.S., STEM initiatives from institutional organizations to government agencies have pushed the narrative that receiving STEM education is critical to inform and prepare future generations to be more competitive in a globalized world [1]. In this sense, STEM education is touted as a cure-all to prepare citizens for the 21st century, and we as educators "ate this up" without as much as a critique. The current model of STEM education narrowly focuses on science as both non-normative (e.g., data gathering, observation, predictions, scientific methods and processes) and normative (e.g., prescribing courses of action, choosing to create selected products, decisions about what ought to be done), with more focus on the non-normative component, all the while ignoring the sociocultural and political implications that exist in our everyday lives [2]. In the context of engineering education, these same views hold true.

Professor Donna Riley and other authors in engineering education research have been investigating the consequences of ignoring the sociocultural and political spheres in engineering education and practice through the lens of social justice [3, 4]. In parallel to STEM initiatives, initiatives in engineering education narrowly focus on diversity, paying sole attention to

recruiting and retaining women and minorities in engineering fields while failing to address the existing "leaky pipeline" [6]. While these efforts to diversify thoughts in engineering are important, they only address one of the symptoms of social injustices in engineering education and ignore the underlying cultural problem which permeates into engineering practice, and in a broader context, to our society. The symptoms of social injustices in engineering are hardly acknowledged and are seen as part of the culture. We the authors have experienced these injustices in our own engineering education, and similarly have seen these injustices creep into design education as we work in both the engineering and design colleges on our campus.

What we have seen from our students is this:

Design students mostly feel marginalized when it comes to technological and engineering literacies. They mostly feel that way since they either did not have a good experience in their technical and engineering classes, or did not like what they saw in technology in their schooling [7]. It is important to note that a majority of design students who feel this way have transferred to design from an engineering major. In contrast, engineering students mostly feel that the process of Design Thinking is a nice set of pictures to help them think about the considerations of human-centered design, but they still continue to be specification driven and deliver their design within the given tolerances [8]. In general, unless they are in special programs, most of the engineering design classes do not emphasize empathy with the user in which human-centered design is the approach to problem-solving. Engineering courses are not within the open, multidimensional space that design students are used to.

What we are seeing is a disconnect of technological literacy from design students, and inversely, a disconnect of design literacy from engineering students. Ideally, we want both sets of students to understand their roles as designers and engineers from a sociotechnical perspective---how what they do in practice affects people and society. These experienced disconnects manifest in poor learning or negative feelings in our students due to how we as educators are presenting and transferring knowledge. When we educate students in any literacies, the students have to understand and connect with different sets of knowledge which include the social and cultural norms in their daily lives. Engineering educators, researchers, and students alike need to be aware and better understand what our roles are within the different cultures we operate in, and be ready to actively reflect on ourselves and the current engineering culture to better design the engineering education system. In this sense, we need to identify the ways we are helping to contribute to social injustices in engineering culture. The purpose of this paper is to open up the discussion on how a modern literacy approach can provide a social justice perspective to engineering education to better suit 21st century needs.

Literature Review

Engineering Culture: Practice and Education in the 21st Century

If one were to ask an outsider what they think of engineering, they would probably say or assume that the engineers are smart, socially awkward, maybe arrogant, and mostly male. Similarly, during the 2017 Grace Hopper Conference, Melinda Gates jokingly described engineers as "a sea of white dudes", while sharing an image of her husband Bill Gates' face[1]. We can see these stereotypes continually appear in comic strips, movies, and social media [9]. These stereotypes create barriers for women and minorities interested in engineering careers [10]. The persistence of these stereotypes are so strong that diversity initiatives are the main recruiting and retaining tool in engineering education and practice. Diversity initiatives in engineering are much needed, but only address surface level issues. We need to dig deeper into the culture of engineering to make effective change.


Figure 1. Dilbert comic strip on google engineers. Scott Adams. December 27, 2013.
https://dilbert.com/strip/2013-12-27

Cech has found that over the course of engineering students' education, their beliefs in the importance of professional and ethical responsibilities, understanding the consequences of technology, understanding how people use machines, and social consciousness all decline [11]. Meaning, engineering graduates go into industry with little regard to public welfare. The problem is not that human-centeredness is missing in engineering education. It is that human-centeredness in engineering education is seen through the lens of specification driven design. We need to question how engineering education came to be too heavily technical. If we look at ABET accreditation criteria, it puts more focus on technical aspects of engineering education [12]. However, it seems misaligned with its code of ethics which states that engineers should put "the safety, health, and welfare of the public" first. This code of ethics is similar across many engineering professional societies. The general premise of all of the codes of ethics

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[1] Nickelsburg, M. (2017, October 04). Melinda Gates on women in tech, her first love, and the origins of Comic Sans. Retrieved February 21, 2021, from
https://www.geekwire.com/2017/live-melinda-gates-grace-hopper-celebration-women-computing/

is to make sure the members, and the engineering practitioners are aware of social responsibilities.

We would like our engineering graduate to be aware of any consequence of our designs that would harm the user, or would have any negative impact on people's lives and well being. However, studies show that engineering education also needs more in depth discussion and education on social justice and equity [4,5]. While the codes of ethics are important, they summarise statements that are hoping to convey a deeper message reflecting the importance of impacts that engineering designs, and artifacts on people's lives, societal and economical impact, and long term environmental impact. These issues need to be discussed, debated, and be a part of engineering students' education. This calls for evolving our teaching practices, understanding the client, and redefining the role of the engineer [13]. Ultimately, what we do in engineering education will eventually transfer to engineering practice. The platform that we need to bring all of this together has to have social justice, equality, and sociotechnical, and cultural considerations.
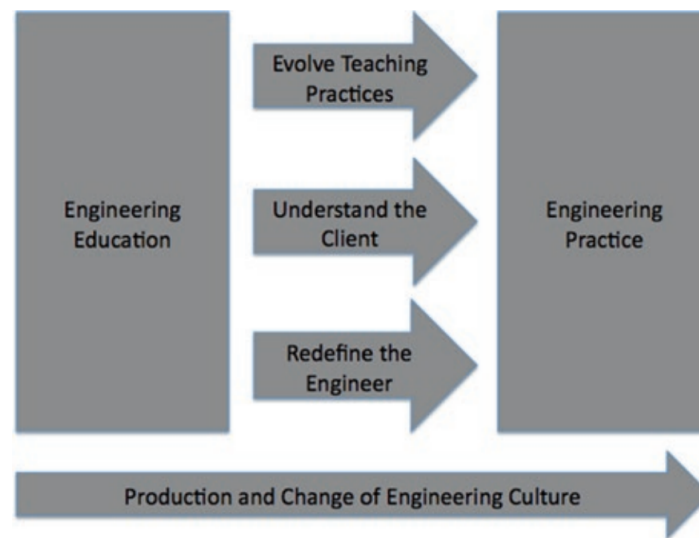
Figure 2. Engineering education as it permeates into engineering practice [13].

To make change in engineering culture we need to understand how it operates on deeper levels. This requires systems thinking. A systems thinking perspective helps to uncover systemic behavior; it is understanding that within a system, all of the parts that create the whole are interconnected, interrelated, or interdependent with each other and form a complex and unified system with a specific purpose [14]. The Iceberg model is a core element in systems thinking and argues that the tip of the iceberg, what we see, are described as events and patterns which are caused by what we don't see, systemic structures and mental modes. An integrated model of systems thinking combines the Iceberg Model and other concepts such as feedback loops like causal loop diagrams [15].
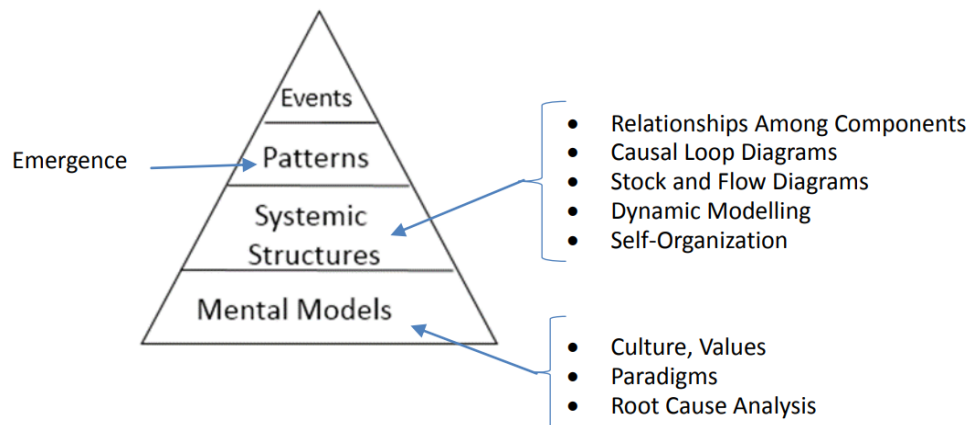
Figure 3. Integrated model of systems thinking [15].

As progress, there have been studies that integrate design thinking and empathy to shift engineering education towards more human-centered design [16, 17, 18, 19]. The hope is that as engineering education shifts from a heavy technical focus to a more balanced focus with the addition of human-centered design, engineering education and practice will be closer to meet 21st century skills and competencies [20, 21, 22, 23].

Social Justice and Engineering
Social justice is intrinsically entangled with philosophical, social, and psychological perspectives, all the while being politically charged. It can contain or be influenced by value systems, belief systems, ideologies, and religious affiliations. Therefore, social justice cannot lend itself to one definition, but to many. Social justice must be as fluid as society itself. It is also important to realize that all working organizations and groups who advocate social justice have their own working definition for it [4]. While there are many common points of focus, naturally there are many differences as well. How could we find a definition of social justice based on engineering, scientific, and design criteria? The answer is that we probably cannot fully define it, but we can try to find, understand and maintain common ideas, hopes, and perspectives that can be functional and meaningful for us in engineering.

Literacy and Engineering
There are few challenges that we need to address when discussing the essence and aspects of Technological Literacy. Defining what is Technological Literacy, while we have been following the discussions on TechTally, is still debated [24, 25]. The Technological and Engineering Literacy and Philosophy of Engineering has been discussing this issue for the last few years, and the discussion is continuing. [26, 27]

In addition, Professor John Heywood has been leading a discussion about the definitions, goals, and forms of Technological Literacy in the last few conferences at FIE and ASEE. These discussions are continuing in ASEE and FIE 2020-2021 conferences [28].

There is scholarly work of technological literacies when dealing with engineering and design in K-12 programs. Interestingly, the discussion at that level also talks about different literacies that students are using. In those cases, since most students are observing and are engaged with their lives and what happens in their families, cities, and schools, they are also aware of social, ethical, and economical implications that are a part of their lives. Those programs do believe that as a part of Engineering and Technological Literacies should include equity, and social justice. [29, 30]

So, it is important for TELPhE to also have a constructive debate on definition as well as inclusion of Social Justice and Equity in Technological and Engineering Literacy. Technological Literacy has been introduced as an important path to informing the non-technical members of society about the importance of technology in our daily lives. We need to accept that this includes socio-technical, socio-political, and challenges that are entangled with our lives at all levels. For that reason, this attempt needs to include informing and empowering the patrons with social justice, equity, and related areas.

Technological Literacy Approach and the Need for Social Justice
Technological literacy has been one of the upcoming challenges in academic fields including engineering, design, and various areas that deal with aspects, application, history, and philosophy of technology and engineering [21]. However, there are debated issues that are being examined and discussed regarding Technological Literacy in academia:

1. Is Technological Literacy an academic area?
2. Are there differences between Technological and Engineering literacy? [31]
3. What are the philosophical perspectives that can enhance understanding, and developing technological literacy? [32]
4. Is technological literacy a complementary knowledge that needs to be focused and modified for different areas such as design, social sciences, history, engineering, and other fields?
5. Are engineering students technically literate when we carefully define the definitions of Technological Literacy?
6. Should a curriculum of technological literacy be created for high school and college level students in different areas?
7. What encompuses technological literacy at all levels?
8. Should technological literacy include social justice?

This paper is not trying to answer some of the above questions. The major goal is to focus on the overall discussions and relationships that connect technological literacy and social justice, and its application in engineering education .

The next step/future work
As we navigate the discussion on literacy, social justice, and engineering, we need to further question our approach: Is technological and engineering literacy enough? Do we need multiliteracies [33, 34, 35, 36]? We look to study works by the New London Group which advocates "design as the metalanguage of multiliteracies" [36, 37].

Conclusion
When we take a step back and look at the broader picture of how overall STEM education is affecting engineering education, we start to see that there exists a systemic problem where human-centeredness is excluded or minimized in favor of an objective view of science and its applications. Ignoring the implications that science presents in our everyday lives contributes to the social injustices that manifest as lack of diversity and lack of empathy across STEM fields, and in this particular case, engineering education and practice.

We want to challenge how literacy is being taught in engineering, specifically technological and engineering literacy. Therefore, any program that is aiming at Technological and Engineering Literacy has to discuss issues of equities, social justice, and other socio-technical challenges that will be entangled with the literacies. Such disconnects and boundaries are experienced in two specific areas, Design and Engineering, and consequently Technological Literacies. That is why, the authors as well as members of the Technological and Engineering Literacy and Philosophy of Engineering Division (TELPhE) of American Society for Engineering Education, have decided to include Social Justice as an inseparable part of TELPhE activities and focus. We believe without inclusion of social justice and realizing the challenges described above, and well studied in literature, this area will not be able to deliver the true mission that is chartered by the members and the original goals of theTELPhE Division.

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