Misinformation in Engineering Design: Plotting a Research and Teaching Agenda for Engineering Education

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Engineering design is often taught as a purely technocentric process. However, a growing number of scholars in engineering education research recognize that developing solutions for people requires making value-laden judgments. These judgements are often against ill-defined, ambiguous, and competing social and/or technical criteria and constraints. For example, in aviation, engineers make decisions based on various sources of information. However, the sources of information accessible to aviation engineers can shape their judgements and decisions, such as the decision to continue flying or ground aircraft with faults [1]. Existing research suggests engineers and managers base these critical decisions on their assumptions, limited available knowledge, operational urgency, and their perceptions of risks [1]. These studies suggest the need to understand how engineers navigate information-rich environments to make import engineering judgements and decisions, with implications for design outcomes, as well as safety for people, communities, and society.

Our work challenges the assumptions of engineering design as purely technical and objective by recognizing the sociotechnical nature of what it means to make judgements and decisions in engineering design [2]. We argue that when engineering designers make decisions about the products and solutions they develop, they are particularly susceptible to the potentially deleterious effects of misinformation and disinformation. Misinformation and disinformation can have an impact on how students engage in engineering design processes, including how they engage with communities, and produce and evaluate artifacts. Because engineering design entails unique social, cultural and cognitive resources, educational strategies used in scientific and technical disciplines to educate engineers may be insufficient for developing students' competencies for navigating misinformation and disinformation in the context of engineering design.

1. What is misinformation and disinformation?

Drawing on Osborne, Pimentel and colleagues [3][4], we define misinformation and disinformation as inaccurate information. While it is common to conflate misinformation and disinformation into one, broad, category of nefarious information, we distinguish these two based on their forms and functions. Misinformation is information offered with good intent while disinformation has malicious intent [3]. For example, scholars have noted that engineers and engineering educators frequently rely on obsolete or simplified science to make challenging concepts more comprehensible [5]. However, in doing so, instructors might also lead students to believe that "school science models, based on obsolete science or idealized setting, provide a correct description of reality" [5, p. 384]. That is, instructors may offer students information in a good-faith effort to help them understand difficult or challenging topics. However, such efforts

may mislead students in their understanding of natural phenomena, leading them to make decisions based on incorrect assumptions and available, limited knowledge of the matter. On the other hand, disinformation is information offered by those who are aware of its inaccuracies or flaws [3]. Disinformation might be intentionally manipulated, as in the creation of deep-fake images and videos that mislead viewers [6]. Disinformation might also entail (a) manipulating data on which important decisions are made or (b) sharing ostensibly true information at strategically nefarious times to manipulate individual or collective decision making. Taken together, the distinction between misinformation and disinformation lies in the motives, intentions, and degree of manipulation of the information itself [2]. Whereas misinformation entails good-faith efforts to inform, disinformation entails intentional efforts to propagate "bad information" with the intent to cause harm, manipulate behaviors, damage the reputations of individuals or organizations, and so on.

2. The Importance of Misinformation and Disinformation Scholarship in Engineering Education

Recently, scholars have pointed to the ways that misinformation and disinformation can become embedded in emerging technologies and solutions, as well as propagated both by users and the technological artifact itself [2]. That is, misinformation and disinformation can inform the design of technological artifacts, which in turn shapes how users engage with technological artifacts. By extension, it also shapes how the artifact itself evolves over time. Shin and colleagues [7] noted that on social media platforms, such as X (formerly known as Twitter), users "depend on each other mutually for certifying false claims and accelerating the spread of rumor" [7, p. 281]. However, the ways users encounter each other, and thus the mechanism by which such false claims are spread, is embedded in the platform itself (e.g., users encounter personalized content that increases the frequency of posts similar to what they have seen before). Others have found that the source of misinformation, "who sends the misinformation or from where the misinformation originated," can impact its propagation [8, p. 5]. Therefore, when engineers design algorithms built into social media platforms that elevate influential actors based on things like follower counts, they also embed within the algorithms mechanisms for propagating misinformation and disinformation [8].

These studies demonstrate the crucial role of engineering decision making in generating and propagating information, pointing to the need to educate engineers on their role and responsibilities for mitigating the impacts of misinformation and disinformation in their work. Still, while studies on the impacts of misinformation and disinformation are growing in number and salience in science education, research on pedagogical strategies that support students' learning related to navigating misinformation and disinformation, particularly in engineering, are less frequent, if non-existent, in the scholarly literature. In a recent published peer-reviewed article [2], we critique the role of traditional information literacy practices in engineering design

education, which often elevate traditionally valorized sources of information focused solely on experts, such as patents and peer-reviewed literature, while marginalizing others, such as community input, social media sites and Wikipedia. We acknowledge the role expertise plays in how we design the world in which we live. However, we argue that pondering expertise in engineering design considerations should also bring together the lived experiences and realities of people in the communities we are designing for and with. We contend that conventional information literacy practices are ill-suited for guiding engineer design learners working in information-rich environments for at least two reasons. First, the lists of "good" sources and "bad" sources of information that students are taught are rarely exhaustive, leaving students ill-prepared for considering sources outside of those explicitly taught in their schooling. Second, the practices we have traditionally used in engineering design education to prepare students in information literacy rarely equip learners with processes and practices for analyzing information sources or establishing the veracity of information other than traditional ones generated by experts during their work.

3. A Research Agenda for Examining Misinformation and Disinformation in Engineering Design Education

This paper seeks to illustrate where and how misinformation and disinformation are manifested in engineering design education. This paper also provides initial thoughts on the pedagogical strategies to support engineering students in navigating a world plagued with misinformation and disinformation.

Engineers, both in educational settings and professional practice, face a deluge of information on which they draw to inform engineering judgements and decision making during the design processes and practices. Prior pedagogical efforts have focused students' attention on institutionally valorized sources of information, often labeled as "good" sources and created by experts. These efforts have also steered students clear of institutionally marginalized sources of information, which are labeled as "bad" sources. Existing research suggests engineers rely on a broad variety of information sources during the design process, and the sources of information engineers draw on may differ at various stages of the design process [2]. However, while a bevy of empirical studies have focused on the cognitive and behavioral activities that the engineering design process entails (e.g., [9][10]), few have attempted to characterize the multitudinous sources of information that engineers turn to when developing solutions and designing technologies for people. We thus propose the following research questions for understanding how information can become embedded in the engineering design process, as well as manifested in design artifacts:

> **Research Question 1:** What sources of information do engineering students draw on to make engineering judgements and decisions during the engineering design process?

Research Question 2: How do the sources of information on which engineering students draw to inform engineering judgements and decision making differ during the various stages of the design process?

Research Question 3: How does misinformation and disinformation influence engineering students' judgments and decision making during the design process?

Engineering students are taught various methodological frameworks for engaging in the engineering design process, such as lean methodology, agile product development, socially-engaged design, human centered design, and design justice. The methodological frame by which engineers engage in the design process shapes the types of information engineers draw on, which may entail different information sources and, by extension, different mechanisms for propagating misinformation and disinformation. For example, Engineer A, who works in industry, might implement agile methodologies by relying on client data, such as marketing data, user experience data, or other proprietary data to select tools and processes, as well as to make engineering judgements during the design process. Conversely, Engineer B, who is engaged in community-based design projects, might rely on ethnographic data, interviews with community members, historical records, and other context-sensitive information sources. While there might be overlaps in the types of information Engineer A and Engineer B collect, there might also be important differences in the information sources on which they draw. These differences have implications for the mechanisms by which misinformation and disinformation shapes their respective judgements and decision making. The differences in information sources, form and function are important to understand in envisioning strategies to train engineers and designers to navigate a world plagued with flawed and malicious information. To the best of our knowledge, existing research in engineering education has yet to examine distinctions between the information gathering techniques and information sources utilized by these differing design frameworks. As a result, engineering design education researchers have yet to investigate the different ways that misinformation and disinformation might be manifested in these different design process models and the potential ways that educators can prepare engineering students to navigate them. We thus propose the following research questions for understanding how design frameworks entail different sources of misinformation and disinformation, as well as different mechanisms for propagating misinformation and disinformation.

Research Question 4: How do students utilizing different design methodological frameworks incorporate different information sources?

Research Question 5: How do different design methodological frameworks expose students to different manifestations of misinformation and disinformation?

To prepare students for the realities they will face as engineers, we must provide the opportunities to learn a variety of processes and practices to scrutinize, corroborate, and validate various sources of information. In engineering design education, we can draw on the work on

media literacy education and science education [3][11][12][13] to bring strategies to combat the advent of the misinformation and disinformation problem. As a result, we will be able to conceptualize new ways to attend to and train the next generation of engineers in processes and practices that individuals and organizations can utilize to evaluate and corroborate information use in engineering design processes. For example, some scholars have outlined procedures for evaluating and corroborating digital information (e.g., [14], [15]). These procedures outline how individuals can scrutinize and discuss information sources, whether and how they scrutinize the evidence presented by the information sources, and how they corroborate information across sources. However, while these broad categories of information literacy practices can inform cognitive and behavioral processes if, indeed, students in engineering design engage in these processes and practices at all, there are of course many methods by which one might scrutinize information. Some general approaches entail establishing the source of the information and/or affirming the veracity of the information. Other more specific approaches for engaging in news and information online go beyond the critical questioning of the sources of information and include explicit steps people can take to navigate a world inundated by inaccurate information such as lateral reading and click restraint [11][13].

We suggest future research and pedagogy in engineering education should expand the scholarship on how to navigate misinformation and disinformation by drawing on prior scholarship in science education and digital media. We propose that a first step could be to examine undergraduate engineering students' approaches to scrutinizing, corroborating, and validating various sources of information in the unique context of engineering design. This line of work should focus on how information literacy processes and practices might differ based on the source of the information and from what engineers do in professional practice. The context of engineering design education is a particularly important one to study the effects of misinformation and disinformation as it requires that engineering students engage in design considerations based on traditionally valorized sources from experts, input from communities, and the virtual and physical realities of the larger society.

> **Research Question 6:** What pedagogical strategies can engineering educators implement to equip engineering students with the cognitive and behavioral competencies to scrutinize, corroborate, and validate different sources of information during the design process?

Finally, scholars examining the role of misinformation and disinformation across contexts have noted that individual sociopolitical values can shape one's susceptibility to misinformation and disinformation [16][17]. While engineering education has long established its legitimacy based on its perceived technocentrism, value-neutrality, technical rationality, and objectivity [2], recent research also increasingly acknowledges engineering design as a sociotechnical process. As a

result, the ways engineers' personal sociopolitical values shape their ways of thinking, knowing, and doing during the design process is of increasing importance [18].

Scholars have already began to study the ways that personal characteristics, such as sociodemographic characteristics (e.g., age, race/ethnicity, gender) and psychological factors shape individual proclivity to form beliefs based on misinformation [e.g., 19-20]. We contend that engineers' sociopolitical values might also shape the ways they engage with various information sources, such as when and to what extent they scrutinize information, the sources by which they corroborate information, and so on. However, to date, little scholarship has examined the role of individual and collective (e.g., within engineering teams, within engineering disciplines) sociopolitical values shape engineering judgements and decision making. Thus, we suggest future research should examine the role of sociopolitical values and beliefs in students' information literacy practices during the engineering design process.

> **Research Question 7:** How do engineers' sociopolitical values shape the sources of information on which they draw to make engineering judgments and design decisions?
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> **Research Question 8:** How do engineering students' sociopolitical values shape their cognitive and behavioral approaches to scrutinizing, corroborating, and validating diverse sources of information during the design process?

The ideas presented in this paper are not intended to be exhaustive; rather, they reflect an emerging and diverse area of inquiry shaping the development of information literacy practices in engineering education and engineering design education. Our intention with this work is to start a crucial conversation on how research can critically examine how, for what purposes, for whom and with whom are engineering students drawing on a wide range of sources of information to inform engineering judgements and decision making during the engineering design process and how we may be able to support them in navigating the perils of misinformation and disinformation in the solutions and technological artifacts that they will design.

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