Awakening Critical Consciousness in Engineering Education: Interdisciplinary Insights and Strategies for Faculty Development

Ms. Jameka Wiggins, The Ohio State University

Jameka Wiggins is a Ph.D. Candidate in Engineering Education, specializing in Organizational Change in Higher Education and Industry at The Ohio State University. Concurrently, she is pursuing a Master's in Engineering Management. Jameka's current research explores how engineering faculties' positionality and lived experiences shape their critical consciousness development. As a scholar and advocate, she seeks to amplify the voices of underrepresented groups in engineering by exploring their experiences, engaging in critical questioning, and offering support. Outside of academic studies, Jameka serves as an ambassador for her department, reviewer for ASEE, and active volunteer for a Columbus STEM non-profit See Brilliance. Jameka has been recognized by her undergraduate institution for her commitment to achieving the vision of the Ronald E. McNair Scholars Program and most recently by her department for her scholarship as a graduate researcher. Jameka strives to be a well-rounded scholar and exhibit her dedication to people and scholarship.

Dr. Monica Cox, The Ohio State University

Monica F. Cox, Ph.D., is Professor in the Department of Engineering Education at The Ohio State University.

Awakening Critical Consciousness in Engineering Education: Interdisciplinary Insights and Strategies for Faculty Development

Abstract

Studies have revealed higher education has a legacy of decentering marginalized voices. Subsequently, faculty are key players in perpetuating and decentering oppressive, exclusionary ideologies that persist in education, as they facilitate students' education, develop pedagogical practices, and create departmental policies and procedures. Exploring methods of raising consciousness and critical awareness can be integral to developing techniques for engineering faculty to assess and reconstruct their professional practices that influence their mindset and reform engineering education.

Introduction

Critical consciousness is an advanced educational pedagogy to liberate the masses from systemic inequity maintained and perpetuated by interdependent systems and institutions (Freire, 1970; Jemal, 2017). It is often situated in the context of analyzing oppressive systemic forces using the cyclic process of critical reflection, critical motivation, and critical action.

Critical reflection is defined as the process of individuals analyzing their reality and social inequities (e.g., economic, racial/ethnic, and gender inequities) that constrain well-being and human agency. Authors argue that individuals who are critically reflective view these inequities and social problems through a systemic lens (Freire, 2020; Watts et al., 2011). Critical motivation also called political efficacy (Freire, 2020; Watts et al., 2011), describes an individual's perceived capacity to affect social and political change through individual and/or collective action. Finally, critical action is a behavioral element referring to individual and/or collective action to counter, respond to, or change injustices in a liberatory manner (Diemer et al., 2015; Watts et al., 2011). Several historical and contemporary definitions of critical consciousness focus on how an individual constructs and reconstructs their reality.

Traditionally critical consciousness development (e.g., consciousness-raising, critical reflection, and engagement in activism) has been explored in racially/ethnically marginalized groups, specifically youth, young adults, and those socioeconomically disadvantaged. Researchers (e.g., Freire (1970), Watts et al. (1999), Diemer et al. (2014)) found that developing the consciousness of these groups can aid in their engagement in action to make social change in their environments as well as realize their ability to produce knowledge.

Literature confirms that group discussion, co-learning, and reflective questioning increase critical awareness and continually develop critical consciousness. These methods can be used with faculty to facilitate their critical consciousness development and serve as a foundation for working against oppressive structures in higher education. In the context of engineering education, studies have explored how implementing culturally relevant pedagogy through ill-structured problems, critical thinking, and humanitarian engineering can facilitate student critical consciousness. However, there is a gap in engineering education literature regarding faculty's use of the components of critical consciousness (i.e., critical reflection, motivation, and action) and factors that have influenced their development as engineering faculty.

Through a review of existing literature and prior research studies, this theoretical paper defines critical consciousness and its employment across various disciplines (e.g., social science and humanities disciplines). It connects existing literature to engineering to uncover potential applications and strategies for faculty consciousness-raising. This paper serves as a foundation for further exploration into the intersection of critical consciousness and engineering education, shedding light on the transformative potential of this multidisciplinary approach to illustrate the intricate relationship between critical consciousness and its prospective utility within the field. A traditional lecture-style format is the preferred method of presentation for this paper.

Literature Review

Critical consciousness renders a lens to analyze how societal structures in higher education perpetuate oppression while providing pathways for collective action to challenge and transform these structures. In the following section, I will review the operationalization of critical consciousness, the components of critical consciousness and its theoretical expansions, and finally, the scholarship of critical consciousness in engineering.

Operationalization of Critical Consciousness

The initial foundation of critical consciousness lies in the advancement of education and strengths or assets (e.g., skills, knowledge, life experiences) among marginalized populations in society. Critical consciousness has several roots, from W.E.B. Dubois' (1897) double consciousness to Paulo Freire's (1970) conscientization and Gloria Ladson-Billings's (1995) culturally relevant pedagogy (CRP). Dubois's double consciousness focused on an inward twoness generally experienced by African Americans' self-perception through the eyes of others and measures themselves based on the world that looks in with immense pity. African Americans ought self (i.e., attributes that one believes one should possess (Bak, 2014)) often limits the achievement of new sight or true self-consciousness because of the conflicting identities of being Black and American (Lloyd, 1972; DuBois, 1897). This perspective delves into the intersectionality of consciousness, exploring the power and oppression conflicts that arise from the overlapping identities of African Americans. While Dubois's double consciousness is not often credited in critical consciousness literature, it holds historical precedence and value given its centering on the racially/ethnically marginalized perspective.

Freire's critical consciousness definition focused broadly on Brazilian men being holders of knowledge and not just recipients. They used this knowledge to transform their realities. To describe this theory, he used the term "conscientization," comprised of two elements (i.e., reflection and action) that are reciprocal and unidirectional. Reflection in his context refers to intellectual awakening that is then combined with action. Action consists of an awareness with praxis to act and enhance their understanding, resulting in fresh reflections (Lloyd, 1972). Freire's (1970) initial work on conscientization was developed into the book *Pedagogy of the Oppressed* which focused on using reflection and action as a "method of liberation from systemic inequity maintained and perpetuated by processes, practices, and outcomes of interdependent systems" (Jemal, 2017, p. 602). Freire revealed contentions with the formal education system, specifically its focus on those who were from the political elitism and neoliberal economic system and the education system's goal to limit human liberation and progress (Trbusic, 2014).

Several scholars have decentered the oppressive ideologies experienced by marginalized groups by focusing on the assets and wealth that exist within their knowledge and experiences. Freire's (1970) critique of the education system has inspired other scholars to delve deeper into the experiences of racially/ethnically marginalized groups, develop contemporary frameworks, and devise methods to assess the various components of critical consciousness. Ladson-Billings (1995) has expanded the use of critical consciousness and critical pedagogy through praxis-focused developments such as culturally relevant pedagogy. Watts et al. (2011) and Diemer et al. (2015) expanded Freire's conscientization through the study of marginalized youth political and civic development. Studies on youth political and civic development have sought to achieve social change and encourage participant learning.

Culturally relevant pedagogy (CRP) is defined as a "pedagogy of opposition not unlike critical pedagogy but specifically committed to collective, not merely individual, empowerment" (Ladson-Billings, 1995, p. 160). Critical consciousness is the third tenet of Ladson-Billings's (1995) CRP extends "a student's efficacy in identifying STEM norms and practices that form visible and invisible exclusionary barriers in STEM programs and STEM fields" (Castaneda, 2019, p. 1). Unlike Freire's initial focus on developing the critical consciousness of men, Ladson-Billings (1995) focused on students, specifically their challenging the status quo. These works have facilitated the development of more contemporary frameworks for measuring and engaging in critical consciousness, especially in K-12 student development and research.

Three Elements of Critical Consciousness

Other contemporary formulations of critical consciousness continue to use Freirean thought. These formulations have sought to address some of the limitations of Freire's initial conscientization work by introducing conceptual models for critical consciousness. This has led to different adoptions, interpretations, expansions, and applications of the components of critical consciousness across various fields (Jemal, 2017). For example, Hatcher et al. (2010, p. 610) use the terms "analytical, constructive, and mobilizing" to portray critical consciousness, while Watts, Diemer, and Voight (2011) expanded Freire's (1970) two components of critical consciousness (i.e., reflection and action) to critical reflection, political efficacy, and critical action.

The context of this paper will refer to the components of critical consciousness as critical reflection, motivation, and action using Diemer et al.'s (2015) definitions because they provide the clearest explanation of each component and limit the use of alternative descriptors or language that are not directly aligned with Freirean thought.

Theoretical Expansion of Critical Consciousness

Several scholars have used Freire's (1970) work as a foundation for their work, highlighting the benefits of his scholarship but also identifying limitations in its theory and practical application. Literature across fields confirms several ways in which critical consciousness is defined and operationalized. This section reviews the work of scholars from psychology (e.g., Diemer and Montero), social work (i.e., Jemal), political science, and education (e.g., Waite, Watts, and Hatcher).

Montero (2009) recognized that Freire's (1970) conscientization limitations in effectively transforming consciousness due to the absence of practical methods, techniques, and thoroughly tested directions. Montero (2009) uses a praxis-based approach to transformation consisting of a process of de-ideologizing and de-alienating using critical reasoning to formulate new understandings of reality. De-ideologization involves the conscious construction and reconstruction of understanding one's reality, while de-alienation is the relation between consciousness and historical and social living conditions of an individual and their awareness of the relation (Montero, 2009). This process provides a more guided approach to how individuals should progress in their critical awareness specifically through the sequence of action and reflection. Like Montero (2009), Jemal's (2017) Transformative Potential sought to address the limitations of conscientization in addition to inconsistencies of critical consciousness theory. Instead of focusing on only oppressed populations, Jemal (2017) believes critical consciousness theory should apply to the oppressor, ally, and all those in between.

Transformative potential uses an intersectional approach to social analysis focusing on both the positions of oppression and privilege as forms of inequity. Additionally, transformative potential acknowledges the interdependence of human existence and thus incorporates a developmental ecological approach guided by Bronfenbrenner (1994) to encompass the interrelationships of systems (Jemal, 2017). Using an ecological approach addresses a limitation in previous critical consciousness literature as it allows for the examination of internalized oppression and privilege. Jemal (2017) seeks to raise the critical consciousness of educators, especially those responsible for producing the next generation of leaders (Jemal, 2017). The transformative potential framework is well-suited for higher education as it addresses oppression and privilege among allies and oppressors. Allies in this context refer to those who support individuals who are oppressed or marginalized, allies seek mutual benefit for both them and those who are oppressed. While the oppressor is defined as an individual who uses their power unjustly and to seek control over others. In addition, the framework promotes raising critical consciousness in educators through introspection and employs an interdisciplinary approach encompassing multiple theories (e.g., critical race theory, intersectionality (Crenshaw, 1991), and critical consciousness).

Like Montero (2009) and Jemal (2017), Waite (2021) developed R.I.S.A.©, a conceptual framework paired with a liberatory pedagogical tool to support the critical consciousness development of instructional supervisory leaders (Waite, 2021). R.I.S.A.© consists of reflection, interrogation, self-examination, and awareness which encourages leaders to practice reflexivity and hold themselves accountable for doing introspective work examining their professional practices (e.g., pedagogy, mentoring style, advising, and leadership philosophies) necessary to facilitate change (Waite, 2021). Like Jemal (2017), Waite (2021) seeks to disrupt internalized racism and oppression as well as existing dysconscious racism that perpetuates the educational system.

Current Scholarship on Critical Consciousness in Engineering

Incorporating critical consciousness into engineering can be a pathway for developing the next generation of engineers who critically question, engage in reflexive praxis, and work toward making meaningful changes to the world around them. Since a large part of engineering involves

critical thinking and design-based problems using teamwork, design, and inquiry-based learning to practice and apply these skill sets, a connection to critical consciousness is a natural one, especially since critical consciousness involves "inquiry-based thinking and needs to be developed through practice" (Kantharajah, 2022, p. 9).

Engineering instructors have been reforming curricula and/or using aspects of CRP in design problems to encourage inquiry-based thinking. For instance, Castaneda (2019) explored how steps could be taken to implement critical consciousness into a broader engineering curriculum through a sophomore statics and dynamics course instead of an isolated concept in an upper-level seminar (Castaneda, 2019). The goal of implementation was to cultivate critical consciousness and social responsibility in engineering students using an ill-structured problem as it would closest resemble a scenario in engineering practice. Additionally, it would encourage students to make judgments, express personal opinions and beliefs, and elicit some of their lived experiences in the development of solutions (Ladson-Billings, 1995; Jonassen et al., 2006; Castaneda, 2019). The authors implemented a survey with statements related to engineering problem definitions and design solutions, social and environmental justice issues, and political awareness related to engineering practice.

Castaneda's (2019) study revealed that data collection outside a quantitative survey model and case study style intervention may be needed to examine engineering students' critical consciousness development. We think this study would have benefitted from a multi-modal model (i.e., incorporating convergence through methods and theories) by incorporating qualitative data collection, such as reflections and interviews, a larger sample size, and a control group that did not receive the intervention (Castaneda, 2019). A key consideration the author overlooked is the cyclical process and time required for the development of critical consciousness. For improved results, it would have been beneficial to conduct pre- and post-surveys, along with the intervention, at the beginning and end of the semester. This would have allowed the instructor to incorporate additional sources of critical consciousness development into the curriculum, enabling a more comprehensive evaluation of students' change over time. Although Castaneda's (2019) results were counter-intuitive, it does not negate the fact that engineers can benefit from the development of critical consciousness.

Like Castaneda's (2019) work Trbušić (2014) proposed that reforming engineering education involves examining and critically questioning engineering curricula and practices. The goal of the work was to introduce a critical pedagogical approach to foster conscientization among engineers, enhancing their ethical acumen by raising awareness about a wide range of pressing issues such as sustainability, environmental protection, poverty eradication, and inequality mitigation (Trbušić, 2014). Trbušić (2014) suggested that educators as well as students participate in critical thinking to question the engineering status quo and re-evaluate accepted truths. Since a major component of critical thinking pedagogy is critical consciousness, Trbušić (2014) argues that teaching methods and components of Paulo Freire's *Pedagogy of the Oppressed* should be incorporated into the daily teaching practices of engineering faculty (Trbušić, 2014).

Kantharajah (2022) has expanded the work of Castaneda (2019) and Trbušić (2014) by exploring ways to implement critical consciousness into engineering pedagogy. Kantharajah

(2022) conceptualized how the theory of critical consciousness could be integrated into engineering pedagogy to produce more socially conscious engineers who advance technologies that will improve gender inequality in education in developing nations. According to the United Nations, within STEM, young women and girls are more marginalized than men, and in developing countries have been denied the right to access fair and equitable education, limiting their pathway to become future engineers and/or leaders in STEM (United Nations, 2022). As stated by Kantharajah (2022), integrating humanitarian engineering into education can enhance the well-being of marginalized individuals and disadvantaged communities. Achieving this goal necessitates a paradigm shift in pedagogy and leadership, wherein educators and students must cultivate critical consciousness. This entails raising awareness about the social, economic, and political obstacles faced by women and girls and equipping engineers with the tools to respond creatively and critically in the dismantling of unjust barriers. (Kantharajah, 2022).

In the context of humanitarian engineering and critical consciousness, learning about generative themes of poverty, sexual violence against girls, and other systemic inequities allow students to think about how they would plan, create, and design technologies to solve those problems (Kantharajah, 2022). Encouraging students to learn about and reflect on these inequities fosters critical reflection and motivates them to envision their roles in driving positive change through their agency and commitment to problem-solving. Additionally, it begins to move students toward critical action and transformation of the social context girls must live in to attend school (Kantharajah, 2022). From this, we learn that engineering must "design, work, and lead with critical consciousness [because it strengthens] their ability to identify injustices, including how technology might contribute to injustices" (Kantharajah, 2022, p. 10). Ultimately, reform in engineering education and the development of future engineers lies in critical thinking, engaging in community contexts with a focus on problem-posing education, and dialogical praxis to reflect and act by being involved in communities and transformation (Trbušić, 2014; Kantharajah, 2022).

Making the Connection

A notable gap the first author identified in the realms of critical consciousness in preparation for her dissertation work pertains to the evaluation of individuals who are in positions of power within the education system, such as supervisors, instructors, and administrators. While critical consciousness has predominantly focused on marginalized communities, youth, and those recognized as oppressed (Jemal, 2017), there is a dearth of research that delves into the perspective of those in power.

Faculty play an instrumental role in student development and can use a critical pedagogical approach to form their engineering identity. There is a limited understanding of engineering faculties' use and development of critical consciousness, however, especially through a critical lens, which is vital to examine as it influences their pedagogical practices, interactions with stakeholders (e.g., students, external community members, other faculty), and knowledge construction. To accurately develop and positively influence students' engineering identity, faculty members must first assess their own professional identities and career decisions as well as how those have come to be.

Strategies for Consciousness Raising

A common theme that emerges from each of the descriptions of critical consciousness is making sense of oneself as one evolves through the process of critical reflection, motivation, and action. It is important to note that critical consciousness development and critical awareness levels may not drastically change since critical consciousness growth is a lifelong journey.

Montero (2009) expresses that critical consciousness development is a constant construction and reconstruction of one's reality as a part of their entire life experience (Montero, 2009). Additionally, Landreman et al. (2007) affirm that the process by which faculty come to be critically conscious does not occur quickly and continues to be a lifelong process. I propose three strategies for engineering faculty to engage in the critical consciousness development and consciousness-raising process: 1) sensemaking, 2) reflective practice, and 3) multi-modal assessment.

Sensemaking

In the context of developing critical consciousness, it is valuable to examine people's context, primarily their surroundings or daily environment. The focus of this section will discuss the development of critical consciousness using sensemaking and how it plays a role in the development of critical awareness. Like critical consciousness, sensemaking is not an endeavor that occurs in isolation or a vacuum of personal interpretations (Horbach et al., 2019, p. 417). Implementing sensemaking paired with the three components of critical consciousness can serve as a guide for faculty to think through how contextual influences, positionality, beliefs, and lived experiences impact their professional actions.

Sensemaking has been defined in several different ways. In the context of this work, it is "the reciprocal process where people seek information, assign it meaning, and act" (Thomas et al., 1993, p. 240). The process of sensemaking allows individuals to create, comprehend, and accept new conceptualizations (Smircich, 1983), which are in alignment with critical reflection and motivation, and then act in alignment with their new interpretations and perceptions (Gioia et al., 1994; Webb & Weick, 1979), which are in alignment with critical action. One of the prominent scholars in sensemaking is Karl Weick, who detailed seven properties associated with sensemaking: identity construction, retrospect, enactment, social contact, ongoing events, cues, and plausibility (Weick & Weick, 1995) (Table 1).

Table 1: Seven Properties of Sensemaking

Property	Definition (Weick, 1995; Eckel & Kezar, 2003)
Identity Construction	Individuals' exploration of their identity about the organization and can occur at the individual and institutional levels.
Retrospect	How people make sense of what has already occurred meaning we are either ahead of our actions or behind them
Enactment	Identifying sensible external environments and bracketing the socially constructed environment in ways that make sense.
Social Contact	Dialogue through interactions with people to create meaning and collective action
Ongoing Events	A process that people must continuously and constantly engage in but can also be disrupted due to the complexities of life.

Cues	Examines the dependent nature of sensemaking on the cues people extract.
Plausibility	Sensemaking must be made reasonable and plausible in comparison to being right.

Each of the seven properties of sensemaking can relate to elements of critical consciousness, below are brief descriptions of how each of the seven properties may aid in developing one's critical consciousness.

Identity Construction- The focus is on individuals exploring their identity within a system. Similarly, in the process of cultivating one's consciousness, it's essential to scrutinize their relationship with the system one operates within. This may entail assessing their contribution to upholding certain ideals, questioning power structures, and contemplating ways to enhance the system's support for individuals within it.

Retrospect- During the retrospect property, the focus is on making sense of what has occurred. This property can be linked to critical reflection as critical reflection focuses on examining historical perspectives and contexts of events. Similarly, the retrospect property is grounded in understanding retrospective experiences. With the application of critical reflection and retrospection, an individual can use both to examine the history of systemic inequities and oppression as well as examine past actions. This application can aid in beginning the process of evaluating the influence those components (e.g., systemic inequities and oppression) have had on their identity, perspective, and other facets of life.

Enactment- This property centers on sensible external environments and brackets those that are socially constructed. This is often influenced by manipulation, interpretation, noticing, and other factors like the framing of the changing environment (Gioia et al., 1994; Webb & Weick, 1979). Additionally, this component aligns with critical reflection because of the emphasis on bracketing historical experiences, recognizing the changes, and understanding the role these influences play in our understanding of oppression. Through the bracketing process, scholars may also be moved to motivation because of the noticing, the framing of changes, and the influences it has on their positionality and beliefs.

Social Contact & Cues- This component focuses on the use of dialogue and connections with people to make meaning. Like the process of developing critical consciousness, sensemaking is an ongoing process that people must continuously and constantly engage in, this process can also be disrupted due to the complexities of life (Weick, 1995, Eckel & Kezar, 2003). The focus on extracted cues is dependent on individuals' ability to extract from the flow of activities, events, and embellishments that arise from human activities. These cues are often familiar structures that influence our knowledge construction.

Plausibility- This property describes how sensemaking is driven by plausibility rather than accuracy (Weick, 1995; Eckel & Kezar, 2003). The limitation of plausibility in this context is the focus that the sense made must be acceptable and credible for those in the organization. Both the social contact and plausibility properties can be associated with critical action as social contact focuses on dialogue and plausibility focuses on implementation. Like Eckel and Kezar

(2003), all these properties can be applied to transformational change and can be examined in the context of critical consciousness but due to limitations some of the components will not be equally applied.

Reflective Practice

Reflective practice is an essential component of professional development and a pathway for critical consciousness-raising at the post-secondary level. Donald Schon (2017) emphasizes the importance of professionals engaging in the ongoing process of reflecting on one's knowledge and practices in real-time (Schön, 2017). Critical scholars (e.g., Brookfield (2000), Fendler (2003), and Larrivee (2000)) stress the need for educators to not only scrutinize their pedagogical practices but also the assumptions that underlay their beliefs regarding teaching, learning, and the broader sociopolitical landscape impacting their professional practices and student outcomes (Hora & Smolarek, 2018).

Faculty can examine their pedagogical practices and assumptions using the three components of critical consciousness to guide their reflection process. There are several methods of reflection faculty can use such as self-reflection, group discussion and co-learning spaces, and reflexive praxis frameworks.

When engaging in self-reflection, faculty can start by examining the development of their positionality. Broadly, positionality describes the dynamic ways individuals are defined by socially significant identity dimensions (e.g., gender, race, and class) (Maher & Tetreault, 1994; Secules et al., 2021). Analyzing faculty's positionality can aid in translating how intersections of their identity are manifested through their lived experiences, especially social interactions (Crenshaw, 1991) which can in turn impact their critical awareness. Rodriguez and Navarro Camacho (2023) affirmed this claim through their study, conducted with science education educators, revealing that an individual's positionality is influenced by their ability to assess their multiple identities and possess critical self-awareness of their identity development (Rodriguez & Navarro-Camacho, 2023). Having faculty members reflect on their positionality allows insight into how they define themselves, the saliency and invisibility of specific identities in comparison to others, and how this has impacted their critical awareness of themselves and others.

Self-reflection can also be facilitated through the examination of lived experiences which is valuable as those experiences can shape their underlying assumptions and current professional practices. Analyzing lived experiences in terms of evaluating faculty consciousness development creates meaning through interpretations of social experiences that can be shaped by cultural norms that in turn inform patterns of thought and behavior (Carlson et al., 2006; Jemal, 2017). Reflecting on lived experiences provides insight into critical incidents experienced by faculty, aids in identifying factors outside of identity construction that have shaped their consciousness and helps them interpret how their environment has influenced the professionals they have become. Having faculty intentionally participate in reflective practice is a valuable tool when evolving one's critical awareness as it provides a way to introspectively assess and document a journey of consciousness-raising. Reflexive praxis frameworks can pair well with self-reflection as they can facilitate introspective assessment.

An example reflexive praxis framework is Waite's (2021) R.I.S.A.© model, a cyclic process that incorporates four stages: reflection, interrogation, self-examination, and assessment. This model was developed for instructional and supervisory leaders (ISLs) as a pathway to shift national and state education departments' approaches to preparing ISLs with a focus on anti-racism, critical consciousness, and culturally relevant leadership. R.I.S.A © incorporates critical theories, critical race theory, and liberatory praxis, which align well with critical consciousness as it requires the oppressed or the oppressor to examine ideologies that have influenced their knowledge construction and use the framework as a guide toward individual change. Additionally, frameworks of this kind encourage educators to genuinely engage in reflexive practice and hold themselves accountable for doing the introspective work that shifts the education climate (Waite, 2021).

While self-reflection is essential to developing consciousness, it is important for faculty to also participate in reflection through group discussion and co-learning environments. Several researchers have identified dialogue as a method for investigating consciousness-raising. Freire (1970) recommended that investigations of critical consciousness be dialogical as it allows the discovery of generative theories and stimulating awareness (Freire, 2020; Jemal, 2017). Landreman et al. (2007) emphasized the significance of open and reflective dialogues within a group context as a pivotal means to cultivate critical consciousness. Engaging in dialogue with other faculty could contribute to the advancement of knowledge, encourage collective and self-reflection, and heighten awareness to foster personal growth in consciousness. However, intergroup dialogue also comes with its challenges as it requires vulnerability, authenticity, and trust between peers. A major barrier to faculty's change in consciousness is their initial unwillingness to engage in dialogue, especially about topics such as race and pedagogical practice (Bok, 2008; Vallejo Peña, 2012). Vallejo Peña's (2012) study reaffirms the findings of Polkinghorne (2004) and Landreman et al. (2007) that institutions must develop self-reflexive activities for faculty to better understand the effects of race and inequities in academic outcomes. Ultimately, using reflective practices can help engineering faculty assess their roles in the perpetuation of dominant ideologies in higher education, identify their moral commitment and agency to seeking change in the education system, and ways to work individually and collectively to change systems in their respective spaces.

Multi-modal

An emerging method is multi-model, which is defined as practices and principles used to explore and understand various constructions of people's realities and experiences (Villanueva Alarcón et al., 2023). Critical consciousness can benefit from a multi-modal approach as it has been assessed through both quantitative and qualitative methods. Traditionally, scholars such as Diemer et al. (2020) and Castaneda (2019) have employed survey models to measure critical consciousness levels. However, it would be beneficial to adopt a multi-modal approach that integrates quantitative measurements and qualitative discussions, enabling a more comprehensive evaluation of critical awareness. The National Science Foundation (NSF) houses multi-modal approaches under the umbrella of convergence research as it combines knowledge, theories, methods, analysis, and interpretation strategies across disciplines (National Science Foundation, 2016). A multi-modal approach using critical consciousness could combine the methods of surveying, participatory action, and reflection. An example of a multi-modal approach to critical consciousness is the use of a quantitative survey like Diemer et al.'s (2020)

Short Critical Consciousness Scale (ShoCCS) paired with reflection prompts guided by a reflexive praxis framework. This approach could be done independently by faculty or in a group setting as a departmental professional development activity.

Implications and Conclusion

There are several implications for engineering faculty to implement strategies for consciousness-raising. I propose four implications: 1) gauge critical awareness, 2) critical thinking and questioning, 3) evaluate bias, and 4) initiate changes in pedagogical practices. These implications are by no means an exhaustive list, but examples of how a critical consciousness framework could be used in an engineering education community.

Gauge Critical Awareness- Engineering faculty often work with various stakeholders like NSF, students, and external community members. It may be valuable before working with these groups for faculty to engage in one of the previously provided strategies to check their assumptions regarding the stakeholder group they are working with. For example, if working with first-year engineering students it may be valuable to self-reflect about pedagogical practices and challenge assumptions you may have about students. Faculty who work with teaching assistants can encourage them to engage in individual reflection using a guide reflexive practice model and then have a group discussion to learn from one another. To address the needs of stakeholders, engineering faculty, and students need to become critically aware of societal structures that impact external parties and possess the cognitive abilities to assess how those structures influence their professional identities and practices.

Critical thinking and project application- This implication focuses on the critical thinking and questioning benefits of critical consciousness in its application in engineering. Critical consciousness entails inquiry-based thinking and can be developed through practice (Kantharajah, 2022, p. 9). Like the ill-structured problems posed by Castaneda (2019), departments and universities can facilitate a similar practice using case studies in professional development workshops. These workshops may encourage faculty to work through realistic situations that call for critical questioning about their professional philosophies, pedagogies, and other practices while thinking through the case study scenario(s) to formulate solutions. Department- or university-level encouragement to participate may create intentional and welcoming spaces for faculty to engage in co-learning with peers. To maintain critical consciousness development, university, and departmental leadership should make at least one workshop required or embedded into routine spaces like faculty meetings. Additionally, these resources should be provided on an ongoing basis to encourage continuous growth and discussion.

Evaluating Bias- This implication focuses on using critical consciousness reflexive praxis frameworks and scales like Waite's (2021) R.I.S.A. © and Diemer et al.'s (2020) Short Critical Consciousness Scale (ShoCCS) evaluates faculty's bias. Bias can exist implicitly, where a faculty is not consciously aware of the biases they hold, and explicitly, where they are consciously aware of their biases. Engaging in a reflexive praxis framework encourages faculty to reflect on their positions in this world. To understand how they are perpetuating implicitly or explicitly oppressive ideologies. These reflections can create new perceptions and encourage them to decenter oppressive exclusionary ideologies and move toward action or develop the capacity to

address inequities. Additionally, the ShoCCS can help pinpoint how they are performing in each component of critical consciousness (i.e., critical motivation, action, and reflection). By examining these results faculty may be able to identify areas of improvement within their consciousness development.

Initiate changes in pedagogical practices- This implication focuses on making the necessary reforms and changes to engineering curricula and practices that are more critically aware of all groups, especially those historically marginalized in the field of engineering. Faculty can leverage critical consciousness to create pedagogies that are inclusive of learning styles, cultures, and diverse backgrounds. This may include introducing hypothetical case studies that center on the knowledge and experiences of international and racially/ethically marginalized students. Additionally, critical consciousness encourages faculty to challenge traditional pedagogical approaches and incorporate practices that promote critical questioning, problem-solving, and collaborative learning that centers students' experiences.

In conclusion, critical consciousness development is a gradual and ongoing process that evolves with time. The development of critical consciousness is a continuous journey rather than a fixed destination. This process requires effort and dedication and involves ongoing learning and unlearning to foster growth in one's critical awareness. By having faculty work continuously on their critical consciousness development, they can be better prepared to engage in critical thinking regarding oppressive societal structures, enabling them to recognize their positions of privilege or disadvantage and take action to challenge unjust systems.

References

Bak, W. (2014). Self-Standards and Self-Discrepancies. A Structural Model of Self-Knowledge. *Current Psychology*, *33*(2), 155–173. https://doi.org/10.1007/s12144-013-9203-4

Bok, D. (2008). *Our Underachieving Colleges: A candid look at how much students learn and why they should be learning More-New Edition*. Princeton University Press.

Carlson, E. D., Engebretson, J., & Chamberlain, R. M. (2006). Photovoice as a Social Process of Critical Consciousness. *Qualitative Health Research*, *16*(6), 836–852. https://doi.org/10.1177/1049732306287525

Castaneda, D. I. (2019). Exploring Critical Consciousness in Engineering Curriculum Through an Ill-Structured Problem. *2019 IEEE Frontiers in Education Conference (FIE)*, 1–5. https://doi.org/10.1109/FIE43999.2019.9028370

Crenshaw, K. (1991). Women of color at the center: Selections from the third national conference on women of color and the law: Mapping the margins: Intersectionality, identity politics, and violence against women of color. *Stanford Law Review*, *43*(6), 1241–1279.

Diemer, M. A., McWhirter, E. H., Ozer, E. J., & Rapa, L. J. (2015). Advances in the Conceptualization and Measurement of Critical Consciousness. *The Urban Review*, *47*(5), 809–823. https://doi.org/10.1007/s11256-015-0336-7

Eckel, P. D., & Kezar, A. (2003). Key Strategies for Making New Institutional Sense: Ingredients to Higher Education Transformation. *Higher Education Policy*, *16*(1), 39–53. https://doi.org/10.1057/palgrave.hep.8300001

Gioia, D. A., Thomas, J. B., Clark, S. M., & Chittipeddi, K. (1994). Symbolism and strategic change in academia: The dynamics of sensemaking and influence. *Organization Science*, *5*(3), 363–383.

Hora, M. T., & Smolarek, B. B. (2018). Examining Faculty Reflective Practice: A Call for Critical Awareness and Institutional Support. *The Journal of Higher Education*, *89*(4), 553–581. https://doi.org/10.1080/00221546.2018.1437663

Horbach, S. P. J. M., Breit, E., & Mamelund, S.-E. (2019). Organisational responses to alleged scientific misconduct: Sensemaking, sensegiving, and sensehiding. *Science and Public Policy*, *46*(3), 415–429. https://doi.org/10.1093/scipol/scy068

Jemal, A. (2017). Critical Consciousness: A Critique and Critical Analysis of the Literature. *The Urban Review*, *49*(4), 602–626. https://doi.org/10.1007/s11256-017-0411-3

Jonassen, D., Strobel, J., & Lee, C. B. (2006). Everyday problem solving in engineering: Lessons for engineering educators. *Journal of Engineering Education*, *95*(2), 139–151.

Kantharajah, R. G. (2022). Critically Conscious Engineers: Reforming Humanitarian Engineering for Gender Equality in Education. *2022 IEEE International Humanitarian Technology Conference (IHTC)*, 6–11. https://doi.org/10.1109/IHTC56573.2022.9998365

Ladson-Billings, G. (1995). *Toward a Critical Race Theory of Education*.

Landreman, L. M., Rasmussen, C. J., King, P. M., & Jiang, C. X. (2007). A Phenomenological Study of the Development of University Educators' Critical Consciousness. *Journal of College Student Development*, *48*(3), 275–296. https://doi.org/10.1353/csd.2007.0027

Lloyd, A. S. (1972). Freire, Conscientization, and Adult Education. *Adult Education*, *23*(1), 3–20. https://doi.org/10.1177/074171367202300101

Maher, F., & Tetreault, M. K. T. (1994). *The feminist classroom. New York: Basic*.

Montero, M. (2009). Methods for Liberation: Critical Consciousness in Action. In C. C. Sonn & M. Montero (Eds.), *Psychology of Liberation* (pp. 73–91). Springer New York. https://doi.org/10.1007/978-0-387-85784-8_4

Rodriguez, A. J., & Navarro-Camacho, M. (2023). Claiming Your Own Identity and Positionality: The First Steps toward Establishing Equity and Social Justice in Science Education. *Education Sciences*, *13*(7), 652. https://doi.org/10.3390/educsci13070652

Schön, D. A. (2017). *The Reflective Practitioner* (0 ed.). Routledge. https://doi.org/10.4324/9781315237473

Secules, S., McCall, C., Mejia, J. A., Beebe, C., Masters, A. S., L. Sánchez-Peña, M., & Svyantek, M. (2021). Positionality practices and dimensions of impact on equity research: A collaborative inquiry and call to the community. *Journal of Engineering Education*, *110*(1), 19–43. https://doi.org/10.1002/jee.20377

Smircich, L. (1983). Organizations as shared meanings. *Organizational Symbolism*, *55*, 65.

Solorzano, D. (2023). *Critical Race Theory, Racial Microaggressions, and Campus Racial Climate: The Experiences of African American College Students*.

Thomas, J. B., Clark, S. M., & Gioia, D. A. (1993). Strategic Sensemaking and Organizational Performance: Linkages among Scanning, Interpretation, Action, and Outcomes. *The Academy of Management Journal*, *36*(2), 239–270. JSTOR. https://doi.org/10.2307/256522

Trbusic, H. (2014). Engineering in the Community: Critical Consciousness and Engineering Education. *Interdisciplinary Description of Complex Systems*, *12*(2), 108–118. https://doi.org/10.7906/indecs.12.2.1

Vallejo Peña, E. (2012). Inquiry Methods for Critical Consciousness and Self-Change in Faculty. *The Review of Higher Education*, *36*(1S), 69–92. https://doi.org/10.1353/rhe.2012.0049

Villanueva Alarcón, I., Anwar, S., & Atiq, Z. (2023). How multi-modal approaches support engineering and computing education research. *Australasian Journal of Engineering Education*, *28*(2), 124–139. https://doi.org/10.1080/22054952.2023.2274513

Waite, S. (2021). Towards a Theory of Critical Consciousness: A New Direction for the Development of Instructional and Supervisory Leaders. *Journal of Educational Supervision*, *4*(2), 65–79. https://doi.org/10.31045/jes.4.2.4

Watts, R. J., Griffith, D. M., & Abdul-Adil, J. (1999). Sociopolitical Development as an Antidote for Oppression-Theory and Action. *American Journal of Community Psychology*, *27*(2), 255–271. https://doi.org/10.1023/A:1022839818873

Webb, E., & Weick, K. E. (1979). Unobtrusive measures in organizational theory: A reminder. *Administrative Science Quarterly*, *24*(4), 650–659.

Weick, K. E., & Weick, K. E. (1995). *Sensemaking in organizations* (Vol. 3). Sage publications Thousand Oaks, CA.