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Challenging the Engineering Egosystem: Reimagining Knowledge and Advancing Epistemic Justice

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Abstract

This paper critiques the epistemic injustice inherent in traditional engineering and engineering education, where rigid epistemic boundaries marginalize alternative ways of knowing. Engineering's dominant status in the knowledge hierarchy—rooted in technical problem-solving, technological change, and value-neutrality—has fostered an "engineering egosystem" reinforcing epistemic exclusion. This egosystem prioritizes self-preservation over interconnectedness, undervaluing diverse knowledge forms and perpetuating epistemic hierarchies favoring scientific and technical disciplines.

I propose shifting from an egosystemic to an ecosystemic approach to engineering knowledge to address this phenomenon. This approach dismantles rigid boundaries by fostering interdisciplinarity, intersectionality, and transdisciplinarity and integrating multicultural perspectives into engineering education. This paper advocates for embedding interconnectedness, compassion, humility, and openness within engineering practices to promote epistemic justice. By doing so, engineering education can become more inclusive and socially responsive, addressing real-world challenges through more diverse and equitable knowledge systems.

This call to action underscores the need for policy reforms and transformative learning experiences that challenge dominant epistemologies and promote social innovation. By integrating marginalized voices and recognizing the relational nature of knowledge, epistemic justice offers a framework for reshaping engineering education and practice to reflect global communities' diverse realities and needs.

Introduction

Experts possess a mindset supported by extensive knowledge, skills, and experiences in a particular field (Berliner, 2008; Cross, 2004; Tan, 1997; Weinstein, 1993). They are considered powerful because their expertise gives them authority and influence over others, particularly in decision-making processes (Crawley et al., 2014). However, it is essential to recognize that knowledge is not merely a possession of experts but a shared resource that evolves through diverse epistemic contributions (Varghese & Crawford, 2021).

Epistemic injustice refers to the systematic exclusion or devaluation of certain groups' contributions to knowledge due to biases regarding their credibility or epistemological frameworks (Fricker, 2007). This injustice manifests as testimonial injustice and hermeneutical injustice. These injustices are perpetuated through the process of othering—where particular ways of knowing are framed as "outside" the dominant knowledge system, reinforcing marginalization (Keet, 2014). In this case, ways of knowing encompasses the diverse methods through which knowledge is produced, including cultural narratives, lived experiences, and artistic expressions. When these ways of knowing do not align with dominant epistemological frameworks, they are often undervalued or dismissed.

Engineering, as a discipline, has historically operated within an epistemic hierarchy that privileges technical and scientific knowledge over alternative knowledge systems. While this structure has facilitated technological advancements, it has also contributed to the marginalization of non-dominant epistemologies, often categorizing them as non-expert or irrelevant. However, expertise is not inherent; it is cultivated through education, training, and practice in a given field, and engineering is no exception (Crismond & Adams, 2012).

Despite this, access to engineering education and professional spaces remains unequal, shaped by barriers related to socioeconomic status, race, gender, and other systemic forms of exclusion. As a result, only those with the opportunity to navigate these barriers gain access to the power and authority to shape engineering discourse, design processes, and technological solutions. This disparity in participation and decision-making reinforces power imbalances in knowledge production, often leading to epistemic injustices that limit the diversity of voices in engineering problem-solving. An epistemic justice approach in engineering seeks to disrupt these power imbalances by fostering inclusive and diverse knowledge ecosystems that value multiple epistemic contributions, irrespective of disciplinary boundaries or social hierarchies (Walker, 2019). By integrating different perspectives, lived experiences, and alternative methodologies, engineering can move toward a more equitable and socially responsive knowledge framework.

To achieve epistemic justice in engineering, it is crucial to recognize knowledge's integrative, inclusive, and diverse nature. One integrative definition of knowledge defines it as "experiential, social, and built holistically, […] interdependent upon and interconnected with the knowledge others acquire" (McHugh, 2017, p. 271). Knowledge is interconnected because it has relationships and connections, and this characteristic is essential for addressing complex problems (Nguyen & Bosch, 2014). These statements mean going beyond engineering's boundaries and recognizing its interconnectedness with different ways of knowing–disciplinary or consuetudinary.

The Engineering Egosystem.

Engineering, as a discipline, has traditionally operated within an epistemic structure that prioritizes technical knowledge over alternative ways of knowing. While this structure has enabled technological advancements, it has also led to exclusions of disciplinary and consuetudinary perspectives. This systemic structure—here referred to as the *engineering egosystem*—is not the result of deliberate exclusion but rather a historical and institutional pattern that shapes how engineering knowledge is produced and valued.

Crocker and Canevello (2017) and Scharmer (2010) have previously defined the *egosystem* as an individual concept from social psychology and economics perspectives. However, this concept also might apply to understanding the engineering subculture. Appling Crocker and Canevello (2017) to the engineering context, the engineering egosystem is motivated to satisfy the self-centered desires and needs of the engineering subculture to maintain its status as an exclusive way of knowing. Like the egosystems from other disciplines, the engineering egosystem promotes behaviors that isolate engineering from others, disregards the desires and needs of alternative ways of knowing, and fuels competitive and divisive attitudes towards them. The engineering egosystem constructs, maintains, and defends boundaries to actively self-preserve positive images of themselves among society and show their worth and value to others. In other words, the engineering egosystem promotes the distinction between what is and is not engineering, creating the Other category.

As a result, the engineering egosystem contributes in the construction of *hard boundaries* between this and other ways of knowing. These types of boundaries seek to build clear-cut limits between "disciplines and concepts [...] [avoiding] softer, more permeable boundaries, regardless of their validity or the educational results" (Detels, 1999, p. 20). Consequently, hard boundaries categorize disciplines into hard-soft and difficult-easy dichotomies according to their development level and rigor (Sarangapani, 2011). It is considered that hard disciplines have a high level of development because they are based on a paradigm (paradigmatic). In the same way, they are considered more rigorous because there are standards, norms, and linear ways of communication that support their practice. However, the case of engineering is more intricate.

From the boundaries perspective, despite engineering being complexly defined (Mody & Kaiser, 2008), it can be roughly considered a field composed of several disciplines (Smith, 2023). Each discipline is focused on solving problems by applying specific scientific by using knowledge from: "physics, chemistry, and mathematics and their extensions into materials science, solid and fluid mechanics, thermodynamics, transfer and rate processes, and systems analysis" (para. 4). In other words, engineering is a field with two levels of boundaries: internal boundaries around each engineering discipline and an overall boundary around the problem-solving core, which is related to the whole engineering practice (Passow & Passow, 2017). Engineering disciplines are rooted in applying scientific principles, mathematical modeling, and analysis in designing and developing engineering solutions for real-life problems (Cunningham & Kelly, 2017; Moaveni, 2020).

Nevertheless, according to Kramer (2022), distinguishing between engineering and other ways of knowing also questions what counts as engineering and what it means to think like an engineer. In her perspective, technical knowledge embodied in rationality, objectivity, and value-neutrality is central to engineering due to its roots in the natural sciences. However, those ways of knowing that are related to empathetic thinking or creative thinking, the roots of social knowledge, are considered outsiders. From the epistemic hierarchy perspective, the outsiders represent the bottom of a vertical spectrum ranked as soft or easy in a knowledge system that determines the position different ways of knowing have based on their value. This hierarchy defines whether a way of knowing is valuable depending on the level of development and rigor that hard boundaries use as bricks, meaning that it is not just about being categorized but also positioned in a rank. Engineering has been ranked high in this hierarchy, just below the natural sciences, in a position that disregards other ways of knowing.

Because of this hierarchization of knowledge, the arts, humanities, and social sciences have been considered the softest/easiest extreme. This distinction has constructed a power relationship that has impacted how different ways of knowing interact with society depending on the practical value level of the organization (Allen, 2017). For example, engineering in Western society is an essential way of knowing that supports society's social, economic, and political development (Lucena & Schneider, 2008). Consequently, this field has been positioned as a dominant way of knowing in charge of technological change and technical problem-solving (Downey, 2005; Wisnioski, 2012). As engineering is considered to solve real technical problems efficiently, organized, and socio-politically neutral, the current economic and political systems value it positively for aligning these values with economic development based on productivity and efficiency. Accordingly, it has caused high technological development but also a culture of disengagement where engineers self-consider aliens to the socio-political context (Cech, 2013).

On the contrary, arts, humanities, and social sciences have been charged with the stereotype of being costly and inefficient, and their aims are usually not seen as clear or valuable. This phenomenon is usually evidenced in nations that value economic progress or link it to social development, which have focused on solving society's problems through mostly engineering-related projects, developing strong engineering career paths, and overlooking other ways of experiencing the world. The Gross Domestic Product (GDP) is a good way to see this distinction in action, seeing that the distribution in the OECD countries is higher concerning scientific and technological development than in other ways of knowing (OECD, 2022). As such, the credibility and value of non-dominant ways of knowing have been questioned continuously.

This phenomenon is evidenced in education's distinction between the subjects and the funding they receive. Over time, STEM education has received more funding than other areas, especially the arts (Heilig et al., 2010). As a result, engineering has been privileged over other disciplines, creating power imbalances where engineers can exert more significant influence over knowledge-making and doing in real-world processes.

Othering and Hierarchizing non-engineering ways of knowing.

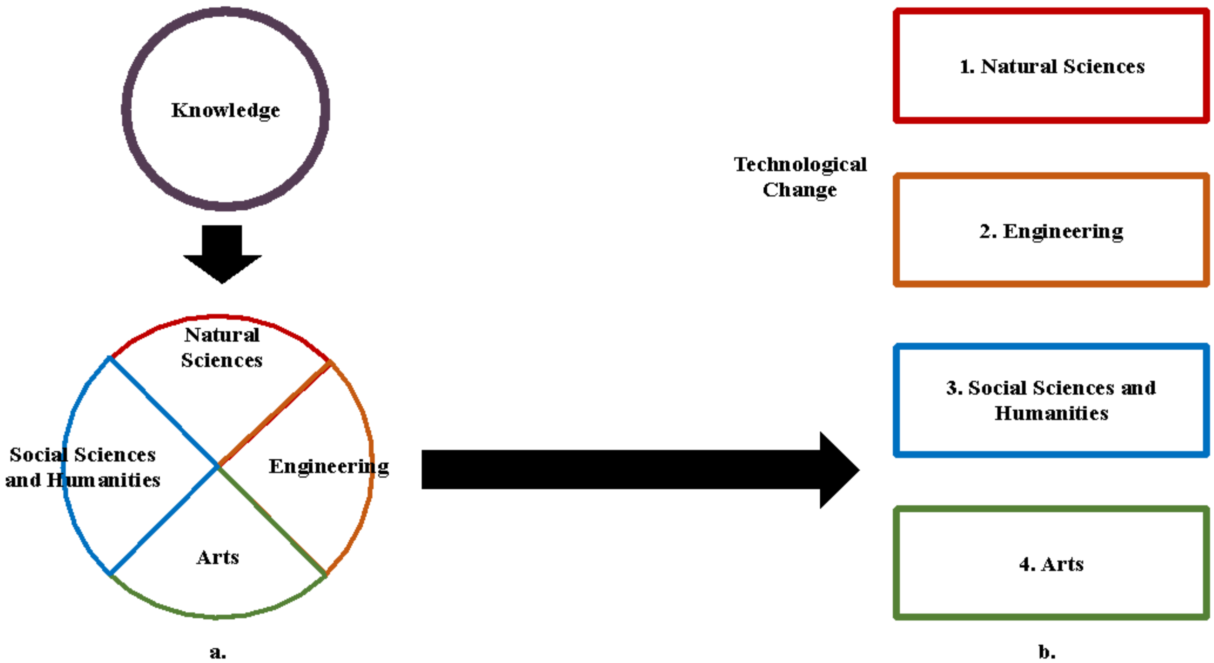
Interconnectedness is threatened when diverse ways of knowing and beings are categorized as others (Kirkpatrick & Faragó, 2015; Mezzenzana & Peluso, 2023; Signäs, 2020). Applied to engineering, this field has evolved as the organized activity tasked with developing and implementing solutions for human wealth (Harms et al., 2005). Historically, it was due to the demand for technical solutions to real-world problems that increased rapidly since the Industrial Revolution, leading to a need for specialized knowledge and skills to develop these solutions and adapt them according to the changing needs of society. In parallel, engineering education and research have multiplied, transforming engineers into key players in solving real-world problems. For instance, engineering was essential to the success of the U.S. during WWII and the Space Race (Akera, 2017), putting this country at the top of the development rankings. Consequently, society granted engineering a high position in a hierarchy that measures the different ways of knowing based on their utility.

This privileged position has resulted in developing a strong and consistent corpus of knowledge, which has helped engineering be perceived as the dominant way of knowing, controlling technological change, and solving technical-based problems. The result is a technology-focused subculture with particular priorities, beliefs, and values, such as rationality, objectivity, and value-neutrality (Kramer, 2022). This subculture also uses its jargon, interacts with people from inside and outside in distinct ways, and depends upon the group's viability and productions (Bucciarelli, 1996). Setting boundaries has allowed a clear differentiation of engineering from different ways of knowing, othering them and reinforcing engineering's power. This promotion of epistemic boundaries, distinction, and distance between different ways of knowing is called *epistemic othering* (Keet, 2014).

As with any other epistemic othering, this defines who is and who is not an engineer, creating a frame based on prejudice and stereotypes that undervalues the ability of the othered ones to control knowledge (Keet, 2014). In the case of engineering, it is related to who owns the power around technological change and technical-based problem-solving. As natural sciences have influenced the engineering subculture, they have avoided its othering, being considered sometimes the core of engineering. However, the social sciences, humanities, and, especially, the arts have been those ways of knowing othered and let outside engineering's boundaries. According to Keet (2014), any kind of epistemic othering is fertile soil for epistemic injustice, emerging from "a lack of collective interpretive resources as a structurally anchored prejudice." (p.24).

Meanwhile, engineering would not be aware of the epistemic injustice it produces; it supports an engineering system that avoids questioning its privileged position in society. Epistemic injustice from engineering pushes to create an *epistemic hierarchy* where the different ways of knowing are ranked according to their value (Kramer, 2022) (Figure 1). In other words, engineering, through the engineers, seeks to preserve its position in society, creating beliefs and practices that maintain other ways of knowing outside its boundaries. In that sense, those ways of knowing that are not aligned with engineering's priorities, beliefs, and values fall into the "others" category. They are also judged for their value to society. This hierarchy is also evidenced in education and academia, where othering is embodied in subjects, areas, fields, or disciplines, supporting the continuation of this whole system.

Figure 1.
Epistemic othering and epistemic hierarchy of the academic knowledge.



Engineering and Epistemic injustice.

Engineering has perpetuated power imbalances where engineers exert more significant influence over knowledge-making and doing in real-world processes. This imbalance can marginalize or exclude diversity of voices and perspectives based on prejudices about their value as knowers. This exclusion is identified by different scholars as *epistemic injustice* (Allen, 2017; Byskov, 2021; Fricker, 2007). These injustices manifest in forms such as hermeneutical and testimonial injustice (Fricker, 2007).

Hermeneutical injustice, as described by Anderson (2012), occurs when marginalized voices lack the “required” understandings, labels, or expressive styles to contribute to knowledge production, particularly in the eyes of those positioned higher in the epistemic hierarchy. Within the disciplines, the arts often find themselves marginalized in efforts to solve real-world problems because, in comparison to engineering, they are perceived as lacking the hegemonic language and style necessary for effective communication. Notably, this injustice becomes apparent only when attempts at communication are made rather than being evident from the outset. Conversely, as Catala (2015) highlighted, *testimonial injustice* involves dismissing or misunderstanding testimony based on the speaker’s social identity. In such cases, different ways of knowing, typically those at higher levels of the epistemic hierarchy, such as engineering, may sideline the “softer” ways of knowing from discussing real-world problem solutions due to stereotypes that portray them merely as supporters of engineering learning rather than active contributors to solution design.

The associations related to engineering and the institutions providing higher education in engineering have played a significant role in shaping this engineering egosystem and, consequently, epistemic injustices. They have broadly recognized the importance of the technical focus on technological change as a fundamental aspect of engineering (Rosenberg, 2009) and promoted the development of supposed value-neutral artifacts that solve problems using specialized knowledge without bias (Cech, 2013).

Challenging Engineering Egosystem.

Although natural sciences, not engineering, are at the highest level of the epistemic hierarchy, the engineering egosystem still contributes to epistemic injustice from its second place. In that sense, engineering has helped reinforce power imbalances and marginalized ways of knowing that are considered soft or easy. According to Crocker and Canevello (2017), the basis of the egosystem is the need for self-preservation which activates the defense of desired self-images. Applied to the engineering egosystem, it can be associated with the defense of engineering's self-image as the dominant way of knowing of technological change and designing technical solutions for real-world problems. However, the engineering egosystem might be costly for engineers' and others' learning, growth, relationships, and well-being (Crocker, 2008).

An integrated approach based on an *ecosystemic*, instead of an egosystemic perspective of knowledge, can help to challenge the power imbalance that favors engineering, promoting a more horizontal approach to technological change and problem-solving. This approach acknowledges that there does not exist a unique or dominant knowledge or way of knowing but that "there are also very divergent bodies of knowledge and different ways of knowing within populations as well" (Barth, 1995). This ecosystemic approach values diverse ways of knowing and expertise. It emphasizes *interconnectedness* and *collaboration*, breaking self-preservation instincts and focusing on species preservation (Crocker, 2008). It includes goals such as caring about other ways of knowing or looking for their well-being by recognizing them in an equal position. Hierarchies are nonexistent, and all voices are listened to in what Dewey and Rogers (2016) defined as an *inclusive dialogue* that allows equality and prizes the quality and number of relations between different ways of knowing. In practice, this inclusive dialogue involves sympathizing, empathizing, and acting to alleviate distress generated by engineering or other sources and promote justice (Williams, 2008).

Achieving an ecosystemic approach to knowledge in engineering requires a mindset change that can be speeded up through interdisciplinary education, echoing Brynes et al. (2022). This approach aims to break down epistemic hierarchies by promoting diverse voices and challenging existing knowledge-making processes (Pfister, 2015). From the engineering education perspective, epistemic justice has been fostered by integrating the liberal arts, particularly social sciences and humanities (Akera, 2017), interdisciplinarity, and multiculturality. As Anderson (2012) suggests about achieving epistemic justice, overcoming the egosystem requires a multifaceted approach.

Epistemic Justice in Engineering Education: A Framework for Inclusive Knowledge Practices.

Traditional engineering education research often emphasizes technical problem-solving and disciplinary expertise. However, this focus creates rigid epistemic boundaries that marginalize non-dominant ways of knowing, including cultural narratives, lived experiences, and artistic expressions (Riley, 2008; Leydens & Lucena, 2018). Epistemic justice offers a transformative framework to address these exclusions by promoting inclusivity, diversity, and interconnectedness in knowledge-making practices within engineering education (Fricker, 2007; D'Ignazio & Klein, 2020). This framework's core is the understanding that engineering knowledge is not value-neutral but shaped by historical, social, and cultural contexts (Harding, 1991; Bucciarelli, 1996). This theoretical shift reshapes how engineering education research is conducted, taught, and practiced.

Epistemic justice refers to recognizing and valuing diverse ways of knowing, especially those marginalized within dominant knowledge systems. It involves two core dimensions:

1. Testimonial Justice: Ensuring that individuals and communities are heard and valued as credible knowers (Fricker, 2007; Dotson, 2012).
2. Hermeneutical Justice: Expanding the frameworks and tools used to interpret and understand the world, particularly in ways that include marginalized perspectives (Medina, 2013).

In engineering education research, this means questioning who is considered an "engineer" and whose voices and knowledge are deemed legitimate (Faulkner, 2000; Slaton, 2015). Traditional research often excludes cultural, artistic, and experiential knowledge, reinforcing narrow definitions of engineering that fail to reflect the complexity of real-world challenges.

Embedding epistemic justice within engineering education should prioritize fostering interconnectedness as a central objective. In this context, interdisciplinarity, transdisciplinarity, multicultural engagement, and the engineering design process are critical spaces to challenge and problematize entrenched epistemic hierarchies within academia. While these approaches are not entirely new, what is novel is the explicit recognition of their potential to advance epistemic justice.

As a result, new values emerge to guide research practices and educational interventions, ensuring that engineering education becomes more inclusive, equitable, and socially responsive. Values such as compassion and empathy highlight recognizing human and social dimensions inherent in engineering problems (Riley, 2008). Interconnectedness underscores the relational nature of knowledge across disciplines, promoting collaboration beyond traditional boundaries. Openness reflects a willingness to engage with diverse ideas, perspectives, and epistemologies. Finally, humility acknowledges the limitations of one's own knowledge and the importance of learning from others, fostering a culture of continuous growth and mutual respect.

Epistemic justice in engineering education research and practice.

Several approaches can be employed to guide epistemic justice in engineering education research and practice. In this section, I will draw from my work to illustrate how these approaches have been implemented in education. This proposal does not imply that my methods are the only way to pursue epistemic justice or that others have not employed similar strategies. What distinguishes my work is the intentional pursuit of epistemic justice as a guiding principle.

One key approach is *interdisciplinary and transdisciplinary curricula*, a powerful strategy to bridge the division of knowledge by affirming diverse ways of knowing as legitimate contributors to technological change and real-world problem-solving. Interdisciplinary collaboration brings together multiple perspectives, fostering creativity and expanding problem-solving horizons beyond traditional technical frameworks. I have explored this by intentionally integrating the arts in engineering education beyond STEAM education and broadening problem-solving methodologies by incorporating creative, non-linear approaches. For instance, I have used shadow puppetry (Vargas-Ordoñez, 2023) to engage middle-school and engineering graphic students in exploring both artistic and technical content and video art (Vargas-Ordoñez, 2024) to explore and question the boundaries of engineering. These methods also provided a platform to amplify marginalized communities' narratives and reflect on engineering work's human and social impact. Such approaches help to dismantle traditional epistemic hierarchies, inviting students and audiences to consider the broader societal implications of their technological innovations. This approach challenges the prevailing notion that the arts are secondary to technical knowledge. Instead, it positions them as essential tools for cultivating compassion, narrative competence, and critical reflection—crucial skills for addressing complex societal challenges.

Another approach is the application of intersectionality, which involves examining how race, gender, sexual orientation, and cultural background shape the experiences of engineering students and influence knowledge production within the field. My research has focused on key questions: Who is included in the engineering design process? (Vargas-Ordoñez, 2024) Moreover, How can engineering education become more inclusive of LGBTQ+, Latin, and international communities? (Baquero-Sierra et al, 2022; Rodriguez-Simmonds et. al, 2024; Vargas-Ordonez et al., 2022). Addressing these questions necessitates critically examining curricular design, admissions policies, and research methodologies to ensure diverse voices are heard and valued in engineering education. By interrogating these structural elements, intersectionality provides a framework to identify and dismantle exclusionary practices, creating more equitable learning environments that reflect historically marginalized groups' lived realities and epistemic contributions.

In terms of educational research methodologies, qualitative and participatory approaches closely align with the principles of epistemic justice by emphasizing inclusion, dialogue, and shared ownership of knowledge (Lincoln & Guba, 1985; Denzin & Lincoln, 2018). *Participatory Action Research (PAR)* involves marginalized communities as active participants in the research process, ensuring their perspectives shape the research outcomes meaningfully (Kemmis & McTaggart, 2005; Cahill, 2007). PAR reflects an epistemic commitment to challenge power dynamics in knowledge production and promotes knowledge co-creation (Reason & Bradbury, 2008). *Narrative inquiry*, through storytelling, offers a powerful method to explore the lived experiences of underrepresented students and educators in engineering education, revealing the often-overlooked human dimensions of learning and knowledge production (Clandinin & Connelly, 2000; Riessman, 2008). Storytelling allows researchers to foreground marginalized voices and create a more inclusive research landscape that recognizes the validity of experiential knowledge (Andrews et al., 2013). Additionally, Arts-Based Research (ABR) utilizes creative methods to push the boundaries of traditional engineering inquiry (Leavy, 2015; Barone & Eisner, 2012). By integrating artistic expression into research practices, ABR challenges conventional epistemological frameworks and fosters more inclusive ways of knowing (Finley, 2008; Irwin, 2013). These methodologies prioritize dialogue, co-creation, and reflexivity, ensuring that research processes and outcomes remain responsive to the diverse needs and realities of the communities involved (Guba & Lincoln, 1989; Smith, 2012).

Potential Impacts of an Epistemic Justice Framework

Epistemic justice in engineering challenges traditional values by reshaping how knowledge is created and whose perspectives are included. It calls for moving from efficiency to care, centering the social impacts of engineering work; from objectivity to humility, acknowledging the limits of one's knowledge and valuing diverse contributions; and from technical rigor to empathy, humanizing the design process. It reframes innovation as justice-oriented and problem-solving as interconnectedness, recognizing the relational nature of societal challenges. By embedding these values, engineering becomes more inclusive and socially responsive, fostering technologies that address the needs of marginalized communities.

Promoting epistemic justice in engineering education requires policy reforms that advance equity and inclusion. These policies must address barriers in admissions, hiring practices, curriculum design, and institutional culture to ensure that historically marginalized voices are represented and valued. Epistemic justice calls for developing transformative learning experiences that empower students to examine existing knowledge hierarchies critically. By fostering self-awareness and critical reflection, students can learn to challenge dominant epistemologies, recognize diverse ways of knowing, and become agents of change in academic and professional contexts.

Epistemic justice also drives social innovation, encouraging the creation of technologies and solutions that address social justice issues, particularly those impacting marginalized communities. By integrating principles of equity and inclusion into engineering design, social innovation becomes a vehicle for advancing justice-oriented solutions that reflect the lived experiences and needs of diverse populations.

Conclusion: A Call to Action for Engineering Education Researchers and Practitioners.

The framework and examples presented demonstrate that epistemic justice is not merely a theoretical concept but a practical framework for reshaping research practices, curriculum development, and the training of future engineers. By embracing values such as compassion, openness, interconnectedness, and humility, engineering education researchers can foster more inclusive knowledge ecosystems that reflect the diverse realities of our world.

This vision demands bold action and a sustained commitment to dismantle the epistemic othering and hierarchization that continue to marginalize non-dominant ways of knowing. The proposed framework advocates for transformation, paving the way toward a new era of inclusive, socially responsive engineering education research and practice.

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