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Grounding Change: Exploring Ambiguity in Geophysical Methods to Foster Decolonized Thinking in Engineering

Alexandra DakotaTomi Brunson, Colorado School of Mines
Dr. Jon A. Leydens, Colorado School of Mines

Jon A. Leydens is Professor of Engineering Education Research in the Division of Humanities, Arts, and Social Sciences at the Colorado School of Mines, USA. Dr. Leydens' research and teaching interests are in engineering education, communication, and social justice.

Dr. Elizabeth A. Reddy, Colorado School of Mines

Elizabeth Reddy is an Assistant Professor in the Division of Engineering, Design and Society at Colorado School of Mines. She is a social scientist, holding a PhD in cultural anthropology from the University of California at Irvine.

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Introduction

Calls for decolonizing curricula have underscored the need for integrating diverse ways of knowing into educational approaches [1], [2], [3], [4], [5], [6]. However, more research is necessary regarding how to cultivate critical consciousness and shift entrenched mindsets among students to make decolonizing engineering possible [7][8]. Efforts to expand students' critical consciousness in academic curricula have gained momentum across disciplines [3], [9], [10], [11], [12]. Such efforts foster awareness of societal power dynamics, inequalities, and oppressive structures while encouraging critical analysis and action for social change. These approaches empower students to challenge dominant narratives, reflect on their roles in systems of privilege or marginalization, and engage as agents of transformation.

Engineering education presents unique challenges for fostering critical consciousness and disrupting entrenched mindsets, largely due to the persistence of Technical/Social Dualism, which upholds a rigid separation between technical and social dimensions of engineering. As a result, the field often resists the integration of epistemologies that fall outside of its narrowly defined framework. When engineering prioritizes technical problem-solving within rigid frameworks, it cannot engage the sociocultural dimensions of its practice [13][14]. This can limit opportunities for cultivating critical consciousness in educational spaces, and create resistance for transformative pedagogy that addresses systemic inequities perpetuated by interconnected institutions and societal structures. Nonetheless, efforts to undertake such pedagogy often emphasize a cyclical process of critical reflection, critical motivation, and critical action, enabling learners to recognize and challenge oppressive forces. Beyond intellectual engagement, these efforts call for purposeful action—empowering individuals to actively dismantle entrenched issues and foster systemic change [3], [9], [10], [11], [12]. Even in engineering classrooms, this kind of work can serve as a vital tool for decolonization, encouraging students to interrogate dominant narratives and cultivate an equitable, justice-oriented perspective.

Decolonization involves using critical consciousness to identify the limits of colonized thinking and remove its harms. It often means calling out colonial normative ideologies (e.g., Western hegemony, meritocracy, power hierarchies, etc.) while re-engaging with alternative, non-colonial epistemologies (sometimes drawing on tools like epistemic humility, community-based research, or reflexivity to facilitate engagement) [2][15]. Rather than a broad or abstract goal, decolonization here is a targeted transformation—cultivating student awareness of the harms of colonization and the benefits of decolonial configurations of existence and agency by fostering cultural humility and integrating epistemologies that challenge dominant colonial frameworks (involving the subjugation of one or more groups of people) [10][16]. While anti-colonialism resists and critiques colonial structures, decolonization extends further–actively constructing alternative ways of knowing and being that emerge from non-colonial epistemologies and relationships. Through this approach, decolonization sharpens the broader aims of critical consciousness, guiding students toward a position of increased awareness and a commitment to disrupting colonial structures in education and knowledge production.

In this context, this study investigates the transformative potential of introducing ambiguous geophysical data with implications for culturally sensitive issues to mostly undergraduate engineering students in the context of Intercultural Communication, a cross-listed (fourth-year and graduate) elective course in a mid-sized U.S. technical university. The guest presenter in the course and first author of this paper is an Indigenous geophysicist, who conducted a study using geophysical tools to detect unmarked graves at a former Indian Residential School.

Geophysical methods are inherently ambiguous because the data they produce is not definitive; rather, it provides a generalized understanding of subsurface features. Interpretation is influenced by various factors, including soil composition, moisture levels, and even the presence of small metallic objects such as belt buckles, all of which can distort signals and complicate conclusions. Additionally, each geophysical technique carries its own set of limitations and uncertainties, reinforcing the need for researcher humility in analyzing results and communicating confidence levels transparently. The three geophysical techniques used in this study included frequency-domain electromagnetics, magnetometry, and ground penetrating radar.

Recognizing this ambiguity can be crucial for good data collection and analysis, but also facilitates breaking down divides between the technical topics considered proper to engineering and the social topics that engineering often excludes. For example, when applying these methods in culturally sensitive contexts such as unmarked grave detection at former Indian Residential Schools, technical uncertainty intersects with historical trauma and sociotechnical responsibility. Geophysical work at these burial sites represent complex intersections of technical, cultural, and ethical considerations. By engaging students with the ambiguities inherent in geophysical methods and their sociotechnical implications, the guest presentation aimed to promote awareness of marginalizing structures and foster a broader recognition of diverse epistemologies within engineering practice. Sociotechnical thinking, defined as engaging "the interplay between relevant social and technical factors in the problem to be solved," encourages students to approach engineering challenges holistically, integrating technical analysis with societal, cultural, and ethical considerations [17]. This perspective seeks a more inclusive and socially responsible approach to engineering, challenging traditional paradigms and expanding students' critical thinking.

By engaging students with sociotechnical thinking by way of the ambiguities inherent in geophysical methods in such cases and then collecting their responses, this study explores *how engineering students perceive and respond to the integration of diverse ways of knowing and cultural knowledge systems, and to what extent they recognize these approaches as valid and valuable contributions to engineering education*. Doing so, it contributes to ongoing efforts to develop pedagogical interventions that promote awareness of marginalizing structures, encourage the incorporation of diverse epistemologies, and inspire a more inclusive, socially responsible approach to engineering practice.

Methods

Study Design

This study utilized a mixed-methods approach to evaluate shifts in critical consciousness among undergraduate and graduate engineering students, including perceptions of colonized and decolonized constructs. Students were given questionnaires before and after a micro-insertion, an approach in which knowledge and/or skills are inserted into a course without "substantial change in the course and in a way students appreciate" [18], that focused on the use of geophysical methods to detect unmarked graves. The combination of quantitative and qualitative methods was selected to better understand how exposure to culturally charged and ambiguous geophysical data influenced student perspectives, both what they think and why. The study aimed to uncover measurable attitudinal shifts while exploring the nuanced reflections that often accompany transformations in thinking.

Participant Demographics

Students came from a wide range of engineering and applied science disciplines (e.g., mechanical, electrical, petroleum, computer science). The course's students were primarily seniors, many of them one or two semesters from graduation. Intercultural Communication fulfills a graduation requirement to complete one senior/fourth-year course. In addition to 21 undergraduates, this course also included five graduate students. All students signed Human Subjects forms approved by the university's Human Subjects Committee.

Pre- and Post-Presentation Questionnaires

Quantitative data were collected as participants completed pre- and post-presentation questionnaires containing seven identical Likert-style questions designed to assess constructs related to identity, objectivity, and the inclusion of alternative knowledge systems (see Appendix 1). The questions were adapted from validated frameworks, including Diemer et al. [16], and used a six-point scale ranging from "Strongly Disagree" to "Strongly Agree." Students were assured response anonymity as questions appeared in i-Clicker Cloud's anonymous mode.

Qualitative data were derived from a post-presentation, open-ended prompt: "*After the presentation, I encourage you to reflect and share your thoughts in this space. Your responses are anonymous. Please be respectful but honest...*". Responses were collected anonymously, allowing students to express their reflections on the presentation and its broader implications for engineering practice. This open-ended feedback encouraged reflections on how the content influenced their understanding of engineering practice, sociotechnical ambiguity, and the value of integrating diverse epistemologies.

Open-ended responses were thematically analyzed through an inductive process attentive to shifts in student discourse around engineering practice and epistemology. Following Case and Light (2014), we treated student reflections as socially situated, recognizing that language reveals deeper cultural assumptions about identity, objectivity, and the role of diverse knowledge systems in engineering [19].

Presentation

Occurring in the third week of a 16-week semester, the presentation by the first author was preceded by the course instructor (second author) accentuating the interdependence of cultural competence and cultural humility and following the guest presentation with readings and discussions on how engineering ideologies can shape the experiences of diverse engineering students (e.g., [20]) as well as contrasts between common engineering/science and indigenous ways of knowing regarding the environment [21].

The presenter’s grandmother endured boarding schools, and her father faced the lasting repercussions of this historical trauma, making the topic deeply emotional and culturally significant for her and other Indigenous people. After the pre-survey, she shared her personal connection to the topic with students in the classroom, fostering transparency and promoting mutual understanding for shared meaning. To prepare any Indigenous students present for engaging with this emotionally-valenced topic, the guest presenter acknowledged the potential emotional risks associated with addressing facets of historical trauma in such a deeply sensitive context. To support student well-being, accommodations were provided, including the option to step out of the classroom if needed and the opportunity to seek additional support privately. These measures were implemented to cultivate a respectful and empathetic learning environment.

The presentation itself introduced geophysical data related to subsurface detection at culturally sensitive sites–a historic Indian Residential School–and framed discussions around sociotechnical ambiguity. Definitive responses about what remains under the subsurface at the Indian Residential School study site were illusive due to that ambiguity. The study also incorporated equity, culture, and social justice themes by framing the presentation within the context of Indigenous knowledge systems [4]. To not influence pre-presentation student questionnaire responses, the instructor did not reveal the presenter’s Indigenous heritage at the presenter's request. The presenter’s heritage was revealed after the initial data collection (pre-presentation) to ensure that preconceived biases did not influence students' initial questionnaire responses. That heritage emerged during the presentation after a discussion of geophysical data, when the presenter’s positionality became a central element, as her personal and familial experiences with these schools informed the presentation’s content, creating an opportunity for students to engage directly with perspectives often marginalized in engineering education.

Results and Findings

Quantitative Results

The quantitative pre- and post-presentation data revealed both notable shifts and persistent ambiguities, reflecting nuanced ways that students engaged with the material. The pre- and post-presentation questionnaire data reveal key shifts in student perspectives in three areas: objectivity, identity, and the integration of cultural knowledge in engineering. Key results derived from the quantitative data focus on five of the seven survey questions (Q3-7, in Table 1), and pre- vs. post-presentation figures appear in Appendix 2 and Appendix 3.

Table 1: Key Pre vs. Post Survey Results

Survey Question	Question Theme	Pre-Presentation Mean Response	Post-Presentation Mean Response	Key Observations
Q3: *As a (future) scientist and engineer, I should be objective in all my work.*	Objectivity in Engineering Work	*3.13* (Somewhat Agree)	*4.44* (Somewhat Disagree)	Shift toward recognizing the influence of cultural and contextual factors that shape objectivity.

Q4: *As a scientist/engineer/ researcher, maintaining a separation from nature (land, other living things, etc.) is essential to preserve my objectivity and agency in my work.*	Separation from Nature in Engineering	*5.11* (Disagree)	*5.11* (Disagree)	Reinforcement of interconnectedness between engineering and the environment.
Q5: *In most engineering projects, cultural knowledge is less important than engineering/scientific knowledge.*	Cultural vs. Technical Knowledge in Engineering	*4.05* (Somewhat Disagree)	*4.05* (Somewhat Disagree)	Same mean but reduced polarization in response spread, suggesting a more nuanced appreciation of cultural knowledge.
Q6: *Although my community of origin is important to me, I prioritize becoming an expert in engineering/science because this expertise offers greater value to society and industry.*	Prioritization of Engineering Expertise Over Community	*4.00* (Somewhat Agree)	*3.50* (Somewhat Disagree)	Increased reflection on the balance between technical expertise and community values.
Q7: *When participating in engineering/science courses at [my university], I must leave parts of my identity at the classroom door.*	Identity in Engineering Classrooms	Mixed Distribution	Mixed Distribution	Continued ambiguity regarding the role of identity in engineering education.

These findings suggest that exposure to sociotechnical ambiguity can foster critical reflection among students, by challenging conventional assumptions – such as the belief that engineering is purely objective and that identity is irrelevant to engineering practice – while reinforcing the importance of cultural knowledge in engineering practice. Q3 (objectivity) suggests a shift toward decolonization through a growing recognition that objectivity in engineering is not absolute but is shaped by cultural and contextual influences. Additionally, Q6 (prioritization of engineering) indicates a growing awareness that engineering and science should not come at the expense of community connections. Reflections related to identity point to an emerging understanding that engineers' cultural background and lived experiences shape their values, problem-solving approaches, and definitions of success – countering the myth of a culturally "neutral" or detached engineer. This decolonizing shift indicates some students moving away from the Eurocentric hierarchy of scientific expertise above "alternative truths," suggesting an emerging understanding that engineering solutions must be relational, culturally responsive, and community serving. From a critical consciousness perspective, this decolonizing shift signals a growing potential to reimagine engineering education–not as culturally neutral in technical skills, but as a space where identity, relationality, and cultural knowledge are recognized as essential to responsible and community-centered practice. Appendix 3 visually represents these shifts, with bar graphs illustrating the means and variability across pre- and post-presentation responses.

Qualitative Findings

The anonymous post-lecture feedback from students offered valuable qualitative insight into how students engaged with sociotechnical ambiguity and the integration of cultural knowledge in engineering. Thematic analysis focused on identifying instances of shifts in critical consciousness and/or evidence of a less colonized mindset. Students' written responses further underscored the complexity of their engagement with ambiguity – some expressing surprise, others resistance, and many articulating deeper reflection on their prior assumptions.

From this analysis, we observed a set of recurring discursive motifs that illustrate students' emerging engagement with complex themes:

· *Epistemic Humility* -- Many students noted the presentation challenged their assumptions about objectivity and neutrality.

Example: "I agree that whilst science is an effective means of discovery, Western society looks to it for absolute truths too often."

Example: "From a social studies perspective, your work is extremely impressive and cool. Thank you for sharing."

· *Differences in Ideological and Identity Starting Points* -- Several reflections indicated that students recognized the influence of their cultural or ideological backgrounds on their initial reactions.

Example: "Leaving my cultural identity at the door of the classroom is something I feel like I must do due to social pressure, not because I want to."

· *Ambiguity as a Strength* -- Students commented on the challenge –and value– of unfamiliar or undefined terms, suggesting a shift toward openness in dealing with complex sociotechnical issues.

Example: "NGL [("Not gonna lie…")] half the term[s] you used I've never seen before. Provide some definition depending on the audience."

Example: "I feel like a lot of the key words used in the questionnaire would specifically need redefining to get a drastic change in the post-results."

· *Cultural Knowledge Integration* -- Reflections emphasized newfound appreciation for the relevance and role of cultural perspectives inherent in engineering practice.

Example: "I really enjoyed the part where you explained how you have become politicized in your research. I wish more people dove deeper into this."

· *Dichotomy Between Technical and Sociotechnical Issues* -- A recurring tension emerged around the perceived boundaries between technical knowledge and sociocultural issues. Some students initially resisted integrating the two.

Example: "The relativism that you hope to introduce to the sciences (from my understanding) I feel has a place beside science, but not in it. Keep on!"

These recurring motifs served as analytical entry points for the development of four broader themes, presented below. These themes reflect a high-order synthesis of student responses, revealing deeper trends in the shifting ways students understand engineering, identity, and cultural integration.

Moving Toward Collapsing Technical/Social Binaries

Students showed increased recognition of the limitations of traditional engineering frameworks in addressing complex sociotechnical challenges after the presentation. While pre-presentation responses showed less recognition of the relevance of cultural knowledge in engineering, post-presentation data indicated a stronger appreciation for its role. Students acknowledged that engineering decisions require both technical and cultural awareness, with one noting, "*Science and engineering would be nothing without context.*" These insights emphasize that students may welcome integrating ethical and cultural dimensions into engineering education.

Recognition of Indigenous Histories and Perspectives

Many students expressed that learning about the historical and cultural dimensions of engineering– particularly through the context of Native American residential schools– broadened their understanding of sociopolitical implications of engineering practice. This exposure disrupted assumptions that engineering is apolitical or culturally neutral. One student noted, "*I didn't really know much (if anything) about Native American boarding schools beforehand*," emphasizing how rarely such topics are included in STEM curricula and how impactful culturally grounded historical context can be for students. These responses suggest that integrating Indigenous histories can foster a more critically conscious understanding of engineering's entanglement with colonial systems and open up new avenues for ethical and relational practice.

Reflection on Biases

The presentation encouraged students to reflect on their internalized assumptions, particularly around identity and belonging with engineering spaces. Students began to recognize the pressure to conform to dominant cultural norms, even at the expense of their own identities. For example, echoing earlier motifs, one student shared, "*Leaving my cultural identity at the door of the classroom is something I feel like I must do due to social pressure, not because I want to.*" This reflection underscores how institutional cultures often marginalize non-dominant identities and how inclusive pedagogical approaches–especially those that make space for culture difference–can affirm and validate the lived experiences of minoritized students. These moments of reflexivity point to the value of critical pedagogies that explicitly invite students to interrogate the role of culture, power, and positionality in STEM.

Persistent Ambiguities and Opportunities

While many students expressed receptivity to integrating cultural knowledge and reflecting on engineering's broader societal implications, some responses–particularly to identity-related prompts such as Q7– revealed unresolved tensions. These mixed responses suggest a persistent ambiguity in how students reconcile technical training with sociotechnical awareness. This ambiguity is not necessarily a failure but a reflection of the discomfort and cognitive dissonance that can accompany epistemic humility. It also highlights the limits of one-time interventions and the need for sustained curricular engagement. These findings indicate a promising opportunity for further research into how longitudinal exposure to decolonial and reflexive practices might deepen student understanding and support the development of more culturally responsive and ethically grounded engineers.

Discussion

Taken together, these findings demonstrate the value of integrating culturally situated, ambiguous content into engineering education as a way to disrupt entrenched assumptions and foster critical reflection. Through both quantitative shifts and qualitative reflections, student responses reveal a growing capacity to hold complexity–both cognitively and affectively–when engaging with identity, history, and sociotechnical ambiguity. At the same time, they point to the emotional and intellectual labor involved in such reflection and raise important questions about how such shifts unfold.

Beyond a micro-insertion, can these attitudinal shifts be sustained over time, particularly in a field that often prioritizes technical and data-driven solutions? What pedagogical strategies are most effective in fostering epistemic humility, especially an appreciation for diverse ways of knowing? How can engineering education meaningfully support students in navigating the tensions between individual identity and dominant disciplinary norms? These questions reflect the ongoing need for research in the evolving understanding of how social and technical issues interface within engineering education and what sustained transformation might require [3][9][10][11].

This study affirms that engineering students are capable of engaging deeply with these themes when given the opportunity. For example, students increasingly recognized that technical and social domains are not separate. Reflections such as "*science and engineering would be nothing without context*" illustrate an emerging awareness that engineering practice is not value-neutral, but deeply embedded within social, cultural, and historical frameworks. This recognition aligns with sociotechnical thinking–the idea that technical challenges must be understood in relation to social, ethical, and cultural contexts [17]. It also resonates with Bartlett et al.'s "Two-Eyed Seeing" framework, which promotes the integration of both Indigenous and Western knowledge systems as complementary, rather than oppositional, ways of understanding the world [2].

Reflections on the historical context of Indian Residential Schools revealed that many students were engaging with these realities for the first time. The inclusion of these narratives challenged assumptions of engineering as apolitical or culturally detached, and affirmed the relevance of historical accountability in technical education. These findings support Brayboy and Castagno's assertion that culturally responsive education helps students challenge dominant narratives and expand the ethical dimensions of their disciplinary formation [15].

Importantly, some student responses signaled moments of defensiveness and ideological resistance, especially when dominant epistemologies were directly challenged. One student remarked, "*The relativism that you hope to introduce to the sciences… I feel has a place beside science, but not in it. Keep on!*" – a comment that, while encouraging in tone, reflects a desire to maintain traditional scientific boundaries. These reactions underscore a key tension identified by Cech [13][14], who notes that engineering culture often socializes students into depoliticized, meritocratic, and objectivist worldviews. As Watts et al. [3] and Jemal [11] emphasize, developing critical consciousness often requires disrupting such deeply held beliefs, which can initially trigger discomfort, skepticism, or even rejection. However, these reactions are not counterproductive–they are indicative of the broader struggle to reconcile inherited disciplinary norms with new, justice-oriented paradigms.

Students also described feeling pressure to suppress aspects of their identity in order to conform to the dominant expectations in STEM, echoing Cech's work on the "culture of disengagement" in engineering education [13][14]. Reflections such as "*Leaving my cultural* *identity at the door of the classroom is something I feel like I must do due to social pressure, not because I want to…*" echo the emotional toll that cultural suppression takes in environments that fail to validate identity as relevant to professional development. These insights support calls for more inclusive pedagogical practices that treat culture and identity not as distractions from technical rigor, but as assets in cultivating reflexive, socially engaged engineers [12][20].

Persistent ambiguities in student responses–particularly regarding identity (Q7) and community (Q6) –illustrate the difficulty of reconciling sociocultural reflexivity with traditionally positivist disciplinary norms. Yet ambiguity is not necessarily a barrier; rather, it can serve as a powerful pedagogical tool. As Watts et al. [3] and Jemal [11] note, discomfort and contradiction are often vital components of critical consciousness development. Teaching students to sit with complexity–rather than resolve it too quickly–can foster deeper engagement with epistemic humility and inclusive problem-solving.
As Freire and Macedo [10] remind us,

> "*The pursuit of full humanity… cannot be carried out in isolation or individualism, but only in fellowship and solidarity; therefore, it cannot unfold in the antagonistic relations between oppressors and oppressed. No one can be authentically human while he prevents others from being so*" (p. 83).

In this light, decolonizing engineering education is not merely about integrating alternative content–it is about relational accountability and collective transformation. Ambiguity, identity, and history must not be treated as peripheral concerns, but as central to how engineers learn, think, and act in the world. When students are invited into this kind of work through culturally grounded, reflexive, and intentionally ambiguous pedagogies, they can begin to reimagine engineering as a relational and ethically responsible discipline. Future curricular efforts must build on these initial shifts, ensuring that sociotechnical complexity is not only acknowledged, but meaningfully embedded across engineering education.

Conclusion

Perhaps the most compelling value of this study lies in the questions it raises rather than those it answers. While Likert-scale questionnaires can tell us students' responses to our questions, they cannot tell us *why* they hold their views or choose to express them as they do. Thus, this study invites future research to better understand why shifts in students' perspectives occurred, and whether such shifts can withstand the test of time and an engineering culture that values the technical and often devalues the social dimensions of engineering problems [13][14].

This study also provides value in raising unanswered, important questions such as: What triggers defensiveness when hegemonic STEM beliefs are challenged? How can engineering education cultivate epistemic humility without alienating students who may feel threatened by these shifts? How can ambiguity be harnessed as a tool to prepare students for the complexities of global engineering challenges? Freire and Macedo [10] remind us that critical consciousness involves solidarity—a collective effort to dismantle oppressive structures while creating inclusive spaces for learning.

Watts et al. [3] and Jemal [11] stress that these transformations require sustained effort and iterative reflection. Engineering educators must continue to explore how these shifts can be supported within and beyond the classroom, particularly in professional practice. How do we ensure that students carry these lessons into their roles as practitioners? What institutional and professional barriers persist, and how might they be dismantled to allow for more equitable and inclusive approaches? These questions point to the necessity of ongoing inquiry and adaptation in engineering education to build a discipline that embraces both technical excellence and cultural humility.

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Appendix 1: Pre- and Post-Presentation Questions

Table 1. Pre- and post-presentation questions with a 6-point Likert scale, ranging from Strongly Disagree... to Strongly Agree.

Question		6 Strongly Disagree	5 Disagree	4 Somewhat Disagree	3 Somewhat Agree	2 Agree	1 Strongly Agree
Q1	Getting good grades is important because I need a high GPA to get ahead.						
Q2	If they work hard enough, all students are positioned to succeed at Mines.						
Q3	As a (future) scientist and engineer, I should be objective in all my work.						
Q4	As a scientist/engineer/researcher, maintaining a separation from nature (land, other living things, etc.) is essential to preserve my objectivity and agency in my work.						
Q5	In most engineering projects, cultural knowledge is less important than engineering/scientific knowledge.						
Q6	Although my community of origin is important to me, I prioritize becoming an expert in engineering/science because this expertise offers greater value to society and industry.						
Q7	When participating in engineering/science courses a[illegible]s, I must leave parts of my identity at the classroom door.						

Appendix 2: Pre- and post-presentation student responses (cumulative). Evolving perceptions about key aspects of engineering. These graphs highlight shifts in attitudes, illustrating how exposure to sociotechnical ambiguity challenges traditional assumptions and fosters more nuanced reflections on success, equity, and the influence of sociocultural factors in engineering.

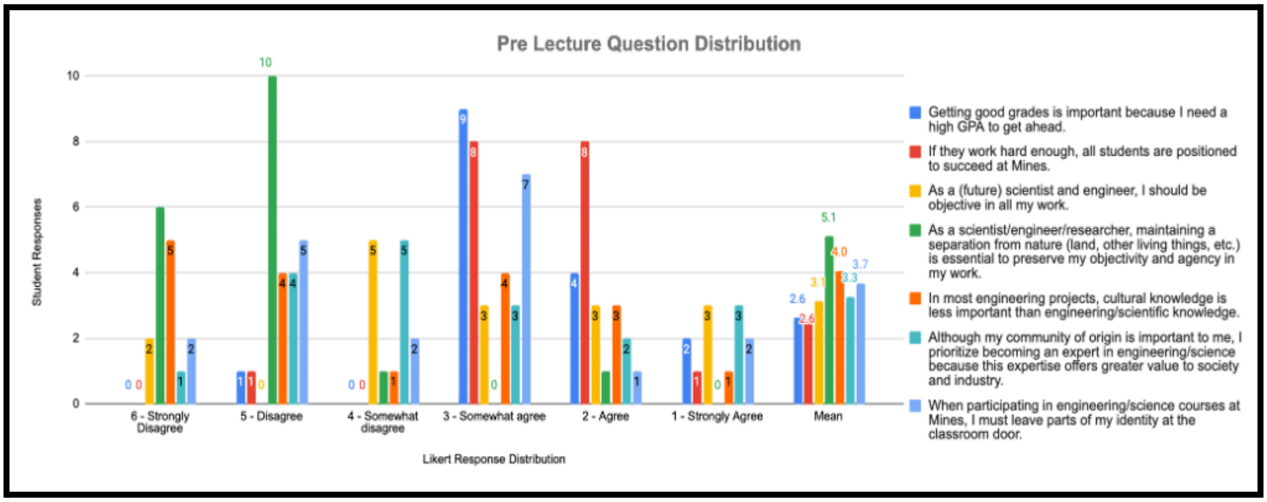

Figure 1 Pre-presentation distribution of student responses to Likert-scale questions, illustrating initial perspectives on topics such as academic success, objectivity, cultural knowledge, identity, and community values in engineering. The graph provides a baseline for assessing shifts in attitudes post-presentation.

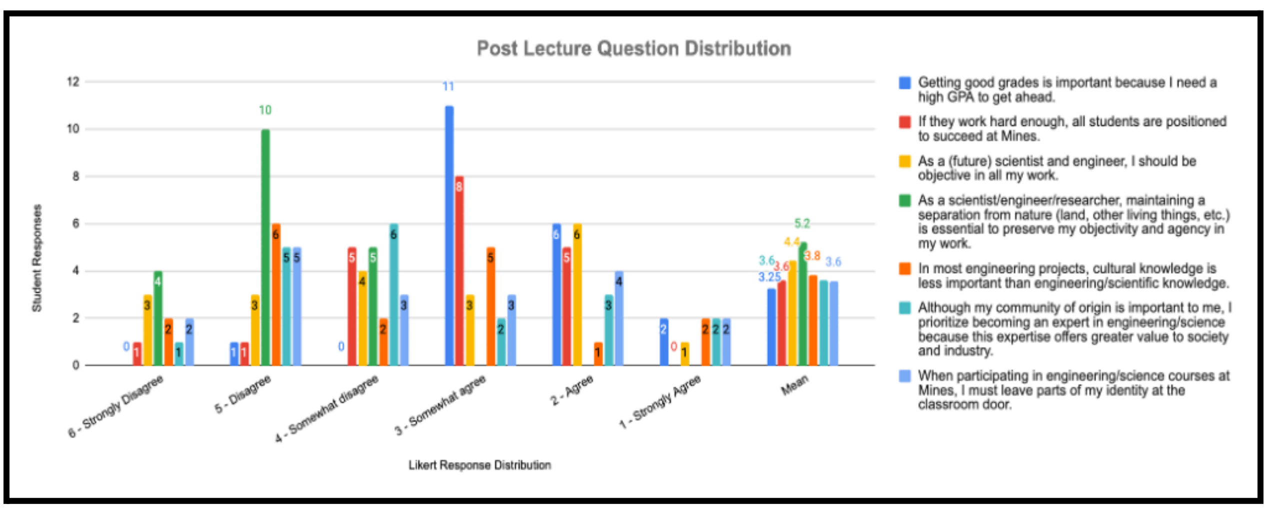

Figure 2. Post-presentation distribution of student responses to Likert-scale questions, reflecting shifts in perspectives on academic success, objectivity, cultural knowledge, identity, and community values in engineering. The graph illustrates changes in attitudes following the presentation.

Appendix 3: Pre- and post-presentation student responses.

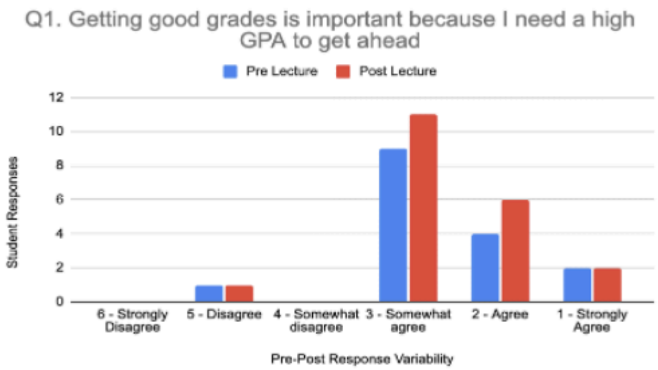

Figure 3. Question 1

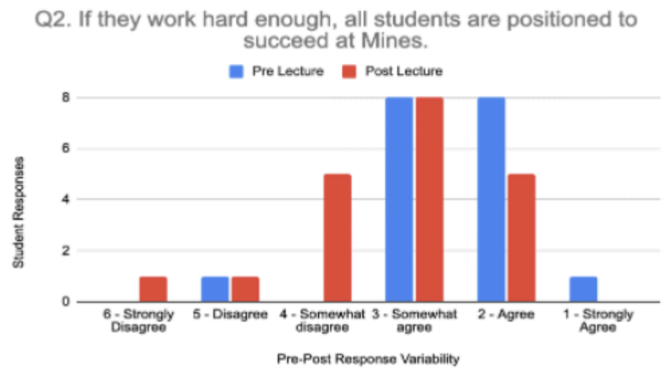

Figure 4. Question 2

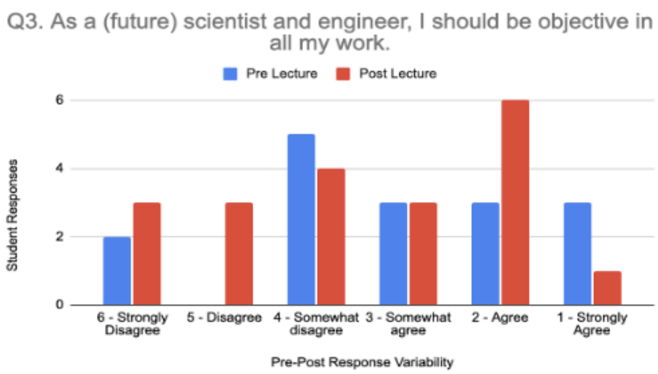

Figure 5. Question 3

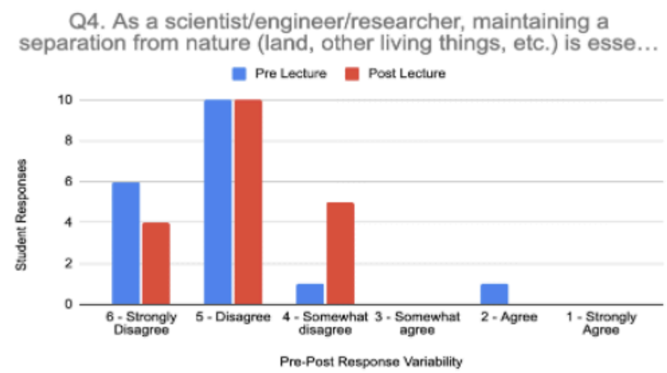

Figure 6. Question 4

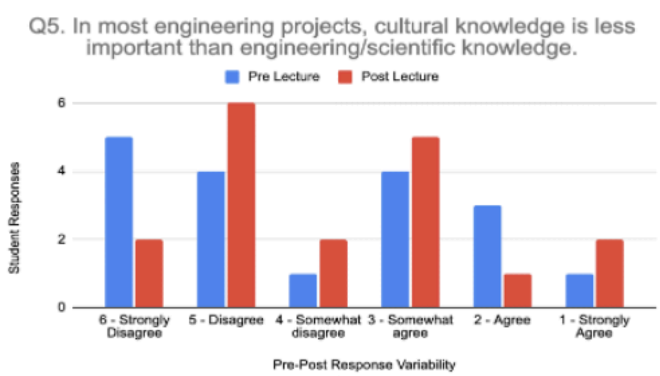

Figure 7. Question 5

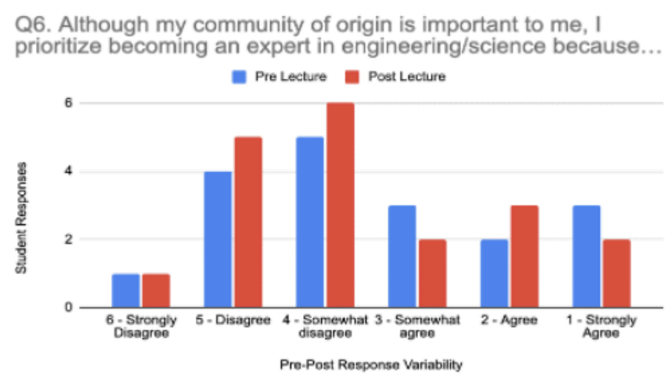

Figure 8. Question 6

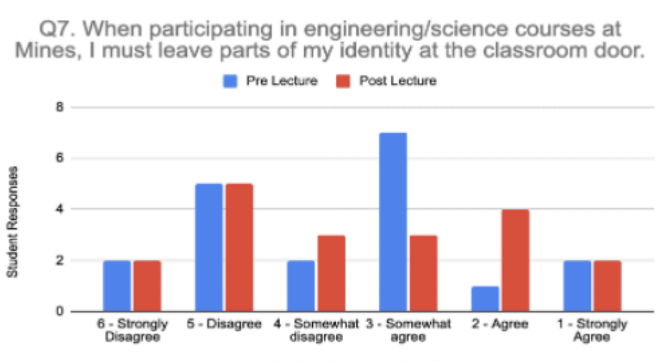

Figure 9. Question 7

Figure 4-9. Pre- and post-lecture response graphs show variations in student perspectives on academic success, meritocracy, objectivity, cultural knowledge, identity, and the role of community in engineering practices. These visualizations highlight changes in attitudes before and after the lecture.