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Tackling 'Wicked' Problems: fostering intercultural competence to improve STEM students' sense of belonging and enhance undergraduate education [Traditional Research Paper]

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Introduction

In an increasingly globalized world, the engineering profession demands not only technical expertise but also a keen understanding of cultural diversity and inclusive practices. Engineering education, therefore, must equip students with the skills needed to navigate diverse professional environments and foster a sense of belonging (SOB) among all students, especially those from historically underrepresented groups. Sense of belonging, defined as the feeling of being accepted, valued, and included within a community, has been widely recognized as a critical factor influencing student success, retention, and overall well-being in higher education [1], [2].

While previous research has highlighted the importance of orientation workshops, extracurricular activities, and peer support in enhancing SOB [3], [4] limited studies have explored the role of faculty, particularly those trained in intercultural competency, in cultivating an inclusive classroom environment. Intercultural competency is a multifaceted construct involving the ability to communicate effectively, demonstrate empathy, and adapt behavior across cultures. It encompasses key dimensions such as openness, curiosity, empathy, communication, and adaptability—skills that are increasingly vital in a diverse and interconnected world [5].

This study examines whether engineering professors trained in intercultural competency can positively impact students' intercultural competence and subsequently enhance their SOB. Humanitarian engineering programs, which integrate engineering solutions with community needs and cultural contexts, serve as an ideal platform for exploring these dynamics. By embedding ICC training into these programs, faculty can model inclusive behaviors and encourage students to engage meaningfully with culturally diverse peers and communities.

The importance of this study lies in its potential to inform engineering education practices that foster a supportive and inclusive academic environment. Students' interactions with faculty, peers, and community members are critical in shaping their educational experiences and their sense of belonging within the STEM fields. For underrepresented students, these interactions can either affirm their place in the engineering community or exacerbate feelings of isolation and exclusion. Therefore, understanding the impact of ICC-trained professors on student SOB is crucial for developing effective interventions aimed at improving diversity, equity, and inclusion (DEI) in engineering education.

The methodology employed in this research combines qualitative and quantitative approaches to capture the nuanced ways in which interventions targeting ICC influences student outcomes. Through pre- and post-semester surveys, end-of-semester interviews, and reflective essays, this study provides a comprehensive assessment of the relationship between ICC and SOB. The findings will offer practical insights for faculty development programs and suggest pathways for embedding ICC training across engineering curricula.

Moreover, the study contributes to the broader discourse on educational equity by highlighting the role of culturally competent teaching in mitigating the systemic barriers faced by

underrepresented students. By fostering an inclusive and culturally aware classroom environment, ICC-trained professors can help bridge the gap between diverse student populations and the traditionally homogenous engineering community. This research not only underscores the importance of faculty development in enhancing SOB but also advocates for a systemic shift towards inclusive pedagogical practices that are responsive to the cultural dynamics of the student body.

In sum, this paper explores how ICC training and interventions used by engineering professors can elevate student intercultural competency and enhance their sense of belonging in academic and professional settings. The results of this study aim to provide actionable recommendations for engineering educators and administrators seeking to create more inclusive and supportive learning environments. By equipping faculty with these skills, we can foster a culture of inclusivity and belonging that empowers all students to thrive in their engineering education and future careers.

Background and Review of Literature

The concepts of intercultural competency (ICC) and sense of belonging (SOB) are critical to fostering an inclusive and supportive environment in higher education, particularly in engineering fields, where underrepresented groups often report feelings of isolation and exclusion. Research has demonstrated that a student's perception of being accepted, valued, and supported within their academic and social environment is strongly linked to academic success, retention, and mental health outcomes [1], [2], [3]. Importantly, SOB is shaped not only by institutional structures, such as extracurricular programs and peer networks, but also by the quality of student-faculty interactions and the cultural climate of classrooms.

Historically, interventions to improve SOB have focused on increasing access to resources, such as guidance counselors, academic advisors, and peer mentoring programs. These efforts have been particularly impactful for historically underrepresented students, such as women, first-generation college students, and racial or ethnic minorities in STEM [4]. However, the role of faculty in creating inclusive academic spaces has received comparatively less attention, particularly with respect to their ability to enhance students' intercultural competency (ICC) and its impact on SOB.

Intercultural competency, as defined by Deardorff [5], is the ability to communicate effectively and appropriately with people of other cultures. It involves a combination of cognitive, behavioral, and emotional dimensions, including the capacity for cultural self-awareness, empathy, curiosity, openness, and adaptability. These competencies are particularly relevant in engineering, where professionals often work on global teams and address challenges that require an understanding of diverse cultural, social, and economic contexts. For example, humanitarian engineering programs, which embed cultural and community considerations into engineering design, provide students with opportunities to engage in cross-cultural interactions, making intercultural competence development a natural extension of such curricula.

A growing body of literature highlights the potential of ICC training to improve not only interpersonal communication but also students' ability to navigate complex societal issues.

Studies on global learning initiatives and study abroad programs have shown that students who participate in culturally immersive experiences demonstrate greater awareness of cultural differences, increased empathy, and improved critical thinking skills [6]. Furthermore, ICC is often associated with improved teamwork, as students learn to appreciate diverse perspectives and negotiate shared understandings in collaborative environments.

Despite these documented benefits, few studies have explored the connection between ICC and SOB in the context of engineering education. This gap is particularly significant given the unique challenges faced by underrepresented groups in STEM fields. Students who feel marginalized or excluded often lack access to the informal networks and social capital that facilitate academic success, and they may perceive STEM disciplines as unwelcoming or unaligned with their cultural values. By fostering ICC, professors can model inclusive behaviors and encourage students to engage in meaningful cross-cultural interactions, potentially mitigating these barriers.

Moreover, sense of belonging is deeply intertwined with the broader academic and social support systems available to students. Sarason et al. [7] emphasized that a student's sense of community is shaped by their relationships with peers, mentors, and instructors. Within the context of STEM, this includes both formal support structures, such as advising and academic coaching, and informal interactions that create a sense of belonging within the academic community. Glass & Westmont [1] and Strayhorn [2] further argue that SOB is not a static outcome but a dynamic process that evolves as students navigate their academic journeys. Professors, particularly those trained in intercultural competence, can play a pivotal role in this process by fostering culturally inclusive learning environments.

This study builds upon these frameworks by examining the specific role of ICC-trained professors in humanitarian engineering courses. Humanitarian engineering provides a unique context for exploring these dynamics, as it inherently involves addressing "wicked problems" that require interdisciplinary and intercultural collaboration. Through structured reflections, surveys, and interviews, this research investigates whether professors trained in ICC can enhance students' SOB by equipping them with the skills and perspectives needed to thrive in diverse academic and professional settings.

By focusing on the intersection of ICC and SOB, this study contributes to the broader discourse on diversity, equity, and inclusion in engineering education. It offers actionable insights for faculty development and curricular design, emphasizing the need for systemic changes to create more inclusive and supportive environments for all students. In doing so, it responds to the urgent call for engineering education to not only meet technical demands but also embrace the social and cultural dimensions of 21st-century challenges.

Methodology

This study employs a mixed-methods approach to examine the relationship between professor intercultural competency (ICC) training and its impact on student ICC and sense of belonging (SOB). Through quantitative surveys and qualitative reflections, this research explores how ICC-trained professors in humanitarian engineering courses influence students' perceptions, cultural

understanding, and integration within the academic community. Below, we detail the study's design, participants, data collection tools, and analysis framework.

Study Context

The context of this study is a humanitarian engineering program at a large public university. This program integrates engineering practices with community-based problem-solving, often involving cross-cultural and interdisciplinary collaboration. Professors leading these courses underwent intensive ICC training designed to enhance their ability to foster culturally inclusive classroom environments, model intercultural behaviors, and facilitate student engagement with diverse communities.

Some courses included service-learning components and study trips where students interacted directly with individuals from different cultural and socioeconomic backgrounds. These experiences provided a fertile ground for examining the evolution of students' ICC and SOB as they applied engineering concepts to real-world challenges in diverse settings.

Participants

The participants included undergraduate engineering students enrolled in humanitarian engineering courses during the study period. The cohort consisted of approximately 40 students, representing diverse demographics, including domestic and international students, as well as students from historically underrepresented groups in STEM fields. Participant selection was based on enrollment in courses taught by ICC-trained professors, ensuring that all students had exposure to culturally inclusive pedagogical practices.

Data Collection Instruments

To capture the multifaceted nature of ICC and SOB, the study utilized three primary data collection methods:

- **Pre- and Post-Semester Surveys:** Students completed validated surveys at the beginning and end of the semester to measure changes in their ICC and SOB levels.
    - **Intercultural Competency:** Adapted from established ICC frameworks [5] the survey assessed key dimensions of ICC, including openness, empathy, curiosity, communication, and adaptability. Students rated their self-perceptions on a Likert scale (e.g., "I am comfortable interacting with people from different cultures").
    - **Sense of Belonging:** SOB was measured using items adapted from Glass & Westmont [1] and Hagerty & Patusky [3]. Survey questions focused on students' perceptions of belonging within their academic, social, and STEM-specific communities (e.g., "I feel valued as a member of my engineering program").
- **End-of-Semester Interviews:** Semi-structured interviews were conducted with a subset of participants (approximately 15 students) to gain deeper insights into their experiences and perceptions. The interview protocol included open-ended questions about:
    - Experiences with culturally diverse peers and communities during the semester.
    - Challenges and growth in communication and collaboration.

    - Reflections on the role of professors in fostering cultural awareness and inclusion. Interviews were audio-recorded, transcribed, and analyzed for thematic patterns.
- **Reflection Essays:** As part of their coursework, students submitted end-of-semester reflection essays detailing their intercultural learning experiences. Prompts encouraged students to:
    - Reflect on interactions with culturally different individuals.
    - Identify challenges faced in navigating cultural differences.
    - Discuss how their perspectives on global engineering and community engagement evolved over the semester.

Coding and Analysis Framework

The qualitative data (interviews and essays) were analyzed using a coding framework aligned with six dimensions of intercultural competence: openness, worldview frameworks, communication, empathy, curiosity, and adaptability. Each student's reflections were coded at one of three levels:

- **Developing:** Demonstrating basic awareness of cultural differences but limited depth in understanding or application.
- **Emerging:** Engaging with cultural differences more critically, showing readiness to adapt perspectives and behaviors.
- **Proficient:** Demonstrating advanced intercultural skills, including the ability to navigate complex cultural contexts effectively and empathetically.

To ensure reliability, two researchers independently coded the data, with discrepancies resolved through discussion. This iterative process enhanced the validity of the findings by minimizing individual coder bias.

Quantitative survey data were analyzed using paired t-tests to assess pre- and post-semester changes in ICC and SOB scores. Correlation analyses were conducted to explore relationships between ICC dimensions and SOB outcomes.

Ethical Considerations

The study adhered to ethical research practices, including obtaining informed consent from all participants and ensuring confidentiality of data. Pseudonyms were assigned to students during data analysis to protect their identities. Institutional Review Board (IRB) approval was obtained prior to the study's initiation.

Study Limitations

While the study provides valuable insights, certain limitations should be acknowledged:

- **Sample Size:** The relatively small sample size may limit the generalizability of findings to broader populations.
- **Self-Reported Data:** Reflection essays and survey responses are subject to biases such as social desirability and self-perception inaccuracies.

- **Context-Specificity:** The focus on humanitarian engineering courses may not capture the full range of ICC experiences across other engineering disciplines.

Strengths of the Methodology

Despite these limitations, the mixed-methods approach allowed for a robust exploration of both quantitative trends and qualitative nuances in student experiences. By triangulating data from multiple sources, the study captures the complexity of ICC development and its impact on SOB within the unique context of humanitarian engineering.

Results

The results of this study demonstrate significant growth in students' intercultural competency (ICC) and its correlation with an enhanced sense of belonging (SOB). Data from pre- and post-semester surveys, reflection essays, and interviews reveal that students progressed across multiple ICC dimensions, including openness, worldview frameworks, communication, empathy, curiosity, and adaptability. Below, we present key findings for each dimension, supported by illustrative quotes.

Dimension - Openness

Students demonstrated increasing openness to interacting with culturally different individuals and reflecting on their initial biases. Many students began the semester expressing apprehension about cultural differences but evolved to appreciate and embrace diversity by the semester's end.

- **Developing Level**: Students at this level acknowledged their own judgments and expressed a willingness to change.
    - *Quote*: "There's physical diversity, yes, but there's also diversity of the mind, and I think I kind of shut myself out from people who have different mindsets than me."
- **Emerging Level**: Students in this category actively sought interactions with culturally different others.
    - *Quote*: "At first, I was nervous about meeting people in England because I thought they might judge me for being American. But once I started talking to them, I realized how much we could connect over shared experiences, like soccer."

This progression highlights how ICC training encouraged students to engage more openly with diverse perspectives, a key factor in fostering SOB within engineering programs.

Dimension - Worldview Frameworks

Students developed a greater understanding of the complexities of cultural contexts, particularly in how cultural elements like history, politics, and traditions intersect with engineering challenges.

- **Developing Level**: Students began to recognize the interconnections between cultural elements but often oversimplified their conclusions.
    - *Quote*: "You can't change the economy or traditions without changing everything—it's all connected."
- **Emerging Level**: Students acknowledged the need to understand cultural nuances when addressing complex issues, reflecting on their initial assumptions.
    - *Quote*: "At first, I thought polygamy in Tanzania was misogyny. But later, I realized it's tied to their agricultural systems and how families share the workload. It made me rethink how culture shapes systems."

These reflections indicate that students progressed from a simplistic understanding to a more nuanced worldview, essential for developing global engineering solutions.

Dimension - Communication

Students exhibited growth in recognizing cultural differences in communication styles and adapting their interactions accordingly.

- **Developing Level**: Students identified challenges in navigating communication differences but lacked actionable strategies to resolve misunderstandings.
    - *Quote*: "It's hard to step into someone else's shoes and see how their background affects how they think. I realized that what I thought was rude might just be a cultural difference."
- **Emerging Level**: Students developed the ability to negotiate shared understanding in diverse groups.
    - *Quote*: "I've learned that I'm a very direct communicator, but not everyone responds well to that. I've started stepping back and giving others space to express themselves before jumping in with my opinions."

These improvements in communication were particularly evident in team-based projects, where students needed to collaborate across cultural boundaries.

Dimension - Empathy

Empathy emerged as a critical factor in students' ability to connect with culturally different others. Students learned to suspend judgment and consider others' perspectives, both intellectually and emotionally.

- **Developing Level**: Students began to notice cultural differences but primarily processed them through their own worldviews.
    - *Quote*: "When I first arrived in Tanzania, I thought, 'Why are they so late?' But then I realized it's not about being late—it's just their cultural way of prioritizing relationships over strict schedules."

- **Emerging Level**: Students not only recognized differences but also developed emotional connections with culturally diverse peers and community members.
    - *Quote*: “Talking with the Maasai people about their traditions made me realize how much I didn’t know. It helped me feel more connected to them and to the larger project we were working on.”

Empathy played a key role in fostering SOB by helping students form meaningful connections with peers and community members.

Dimension - Curiosity

Students exhibited a progression from asking surface-level questions to exploring deeper cultural meanings and their implications for engineering practice.

- **Developing Level**: Students showed initial curiosity but hesitated to engage deeply.
    - *Quote*: “I used to think, ‘I have my culture, you have yours, and that’s enough.’ But now I’m trying to be respectfully curious and ask questions without fear of offending.”
- **Emerging Level**: Students asked profound questions about cultural practices, demonstrating an eagerness to understand complex issues.
    - *Quote*: “When I learned that girls in the community miss school because of a lack of water, I started asking questions about how gender, economics, and education intersect. It completely changed how I viewed the project.”

The shift toward deeper curiosity enabled students to better engage with the communities they worked with, fostering a sense of shared purpose and belonging.

Dimension - Adaptability

Adaptability was a critical outcome of ICC training, as students learned to adjust their behaviors and perspectives in response to cultural differences.

- **Developing Level**: Students initially struggled to adapt to unfamiliar situations.
    - *Quote*: “It was hard to adjust when my teammates communicated differently than I did. I felt like I didn’t belong.”
- **Emerging Level**: By the end of the semester, students demonstrated flexibility and resilience in navigating cultural differences.
    - *Quote*: “When I worked on a project in Honduras, I had to adapt to their slower pace and different work style. At first, I was frustrated, but eventually, I saw how it helped us build better relationships and trust.”

Adaptability not only helped students navigate challenges but also reinforced their SOB as they became more comfortable in diverse environments.

Discussion

The findings from this study underscore the transformative potential of intercultural competency (ICC) training in engineering education. By equipping professors with ICC skills, this research demonstrates that faculty can positively influence both the cultural awareness and the sense of belonging (SOB) of their students. This dual impact is particularly important in engineering, where underrepresented groups often face barriers to full participation and engagement.

Key Findings and Broader Implications

The significant improvements in students' ICC and SOB highlight the value of intentionally incorporating cultural awareness into engineering education. Across the six ICC dimensions—openness, worldview frameworks, communication, empathy, curiosity, and adaptability—students showed meaningful growth. This progression reflects the ability of ICC-trained professors to foster a classroom environment that encourages cultural engagement and critical self-reflection.

The apparent correlation between ICC and SOB is particularly noteworthy. Students who developed greater ICC also reported feeling more connected to their peers, professors, and the broader academic community. This finding aligns with prior research on the dynamic nature of SOB, which evolves as students navigate social and academic networks [1], [2]. By enhancing ICC, professors can help students feel more included, particularly those from historically marginalized groups.

Additionally, the context of humanitarian engineering provided a unique opportunity for students to engage with culturally diverse communities while applying engineering principles. Through study trips and real-world projects, students encountered "wicked problems" that required them to navigate cultural, economic, and political complexities. These experiences not only enriched students' learning but also reinforced their sense of purpose and belonging within the engineering discipline.

Study Limitations

While the findings are promising, however, this study – as previously mentioned - has several limitations that must be acknowledged:

- **Sample Size and Context-Specificity**: The relatively small sample size and the focus on humanitarian engineering programs may limit the generalizability of the results to other engineering disciplines or institutions. Future research should expand this approach to other contexts to validate and extend these findings.
- **Self-Reported Data**: Reflection essays and surveys rely on students' self-perceptions, which may be influenced by social desirability or recall bias. Complementing these methods with observational data or third-party evaluations could provide a more nuanced understanding of ICC development.

- **Limited Time Frame**: The semester-long study captures only a snapshot of students' ICC and SOB growth. Longitudinal research is needed to assess the sustainability of these gains over time.
- **Cultural Context of Professors**: The cultural background of the professors themselves may influence how students perceive and engage with ICC training. Future studies should examine how diverse faculty experiences shape student outcomes.

Actionable Recommendations

Based on the findings, several actionable steps can be taken to enhance intercultural competency and sense of belonging in engineering education:

- **Integrate Intercultural Competency Training for Faculty**
  Institutions should prioritize professional development programs that equip faculty with ICC skills. These programs should include workshops, experiential learning opportunities, and ongoing support to help professors model inclusive behaviors and facilitate meaningful cultural engagement in their classrooms.
- **Embed Intercultural Competence into Curricula**
  This content should not be confined to standalone courses or study trips; it must be woven into the fabric of engineering curricula. Assignments, projects, and case studies can incorporate cultural considerations, encouraging students to think critically about the social and global impact of their work.
- **Expand Opportunities for Cross-Cultural Engagement**
  Engineering programs should provide students with diverse opportunities to engage with culturally different peers and communities. This could include study abroad programs, virtual exchange programs, and partnerships with community organizations that emphasize intercultural collaboration.
- **Foster Inclusive Classroom Environments**
  Professors can take specific steps to create a sense of belonging for all students, such as:
    - Actively encouraging diverse perspectives in discussions.
    - Establishing norms for respectful communication and collaboration.
    - Using inclusive teaching practices, such as varied assessment methods and group dynamics management.
- **Support Reflection and Meaning-Making**
  Reflection is a critical component of intercultural competence development. Assignments like guided journals, reflection essays, and debriefing sessions can help students process their experiences and deepen their cultural understanding.
- **Evaluate and Scale Successful Practices**
  To ensure lasting impact, institutions should systematically evaluate ICC-focused initiatives

and scale successful practices across departments and disciplines. Faculty and administrators should collaborate to share resources, tools, and lessons learned.

The Role of Intercultural Competence in Engineering Education

This study contributes to the broader conversation about diversity, equity, and inclusion (DEI) in engineering education. Engineering, as a discipline, has long been associated with technical rigor and problem-solving. However, the challenges of the 21st century—climate change, resource scarcity, and global health disparities—demand solutions that are as culturally sensitive as they are technically innovative. Developing students' ICC equips them to navigate these challenges while fostering an inclusive professional culture that values diverse contributions.

The connection between ICC and SOB is particularly relevant in addressing the underrepresentation of women, racial minorities, and first-generation students in STEM. By creating inclusive spaces where all students feel they belong, engineering programs can improve retention rates and cultivate a more diverse engineering workforce.

In summary, this research highlights the transformative potential of ICC training for professors and its cascading effects on students' intercultural growth and sense of belonging. While the findings are encouraging, they also underscore the need for continued investment in faculty development, curricular innovation, and inclusive practices. Engineering education stands at a crossroads: by prioritizing ICC and SOB, it can not only address systemic inequities but also prepare students to lead in an increasingly interconnected world.

Conclusion

This study demonstrates the significant impact of intercultural competence (ICC) training for professors on student outcomes in humanitarian engineering programs, with clear implications for fostering intercultural awareness, collaboration, and a stronger sense of belonging (SOB) among students. By integrating ICC training into faculty development and course design, institutions can build culturally inclusive environments that empower students to navigate and contribute meaningfully to diverse academic and professional contexts.

Key Takeaways for Community Engagement

This research highlights the following critical elements:

- **Partnership Development**
  A cornerstone of this study was the context provided by humanitarian engineering programs, which inherently emphasize partnerships with communities and organizations. These partnerships served as the platform for students to engage with culturally different individuals, whether through study trips or community-based projects. The emphasis on reciprocal, respectful partnerships modeled the principles of equitable engagement, ensuring students could learn from the communities they served. Developing sustainable, mutually beneficial partnerships is essential for fostering meaningful student engagement and building long-term trust with diverse communities.

- **Project Design and Execution**
  Humanitarian engineering courses provided a structured framework for integrating ICC into project-based learning. Students worked on real-world engineering challenges, such as water access and infrastructure design, where cultural considerations were integral to project success. These projects allowed students to grapple with the complexities of working across cultural, social, and economic boundaries. Future programs should continue to design projects that embed cultural engagement as a core learning objective and provide students with opportunities to apply ICC principles to tangible engineering outcomes.

- **Student Growth and Evaluation**
  While this study did not aim to provide a comprehensive evaluation of educational outcomes, the findings demonstrate the value of structured reflection in assessing student growth. Reflection essays and interviews revealed that students' ICC development was most pronounced when they were encouraged to process their cultural experiences thoughtfully and critically. Rather than focusing on quantitative assessments, programs should prioritize qualitative evaluations that capture students' evolving perspectives and capacities for intercultural engagement.

- **Lessons Learned**
  Several lessons emerged from this research that can inform the future implementation of intercultural competency interventions and initiatives:

    - **Faculty as Catalysts**: Professors trained in ICC played a pivotal role in modeling inclusive behaviors and fostering meaningful classroom discussions. Faculty development programs should explicitly address how professors can facilitate cultural engagement within and beyond the classroom.

    - **Structured Reflection Matters**: Students benefited most when given structured opportunities to reflect on their experiences, both through guided prompts and facilitated discussions. Reflection should be built into the design of every community engagement project.

    - **Cultural Context and Sensitivity**: The success of student-community interactions depended on the cultural preparation students received before engagement. Pre-departure or pre-project training sessions are critical for equipping students with the awareness needed to navigate complex cultural dynamics effectively.

- **Transferability**
  The approaches used in this study are highly transferable across disciplines and institutions. While the study focused on humanitarian engineering, the principles of ICC training, reflective practice, and inclusive pedagogy are relevant to a wide range of educational contexts. Institutions looking to replicate these successes should:

    - Establish ICC training as a core component of faculty development.

    - Incorporate community engagement projects into course curricula, ensuring they are tailored to local cultural contexts.

- Prioritize partnerships that foster reciprocal learning and benefit both students and the community.

Broader Implications

In an increasingly interconnected world, engineering education must prepare students to address complex global challenges that extend beyond technical expertise. By fostering ICC and SOB, educators can help students develop the skills needed to lead diverse teams, engage with communities ethically, and design solutions that are culturally and socially sustainable. For underrepresented students in STEM, these inclusive practices can provide a pathway to greater belonging, persistence, and success within the engineering field.

This study represents a step forward in understanding how ICC training can transform the educational experiences of engineering students. It also emphasizes the vital role of community engagement in shaping culturally competent, socially conscious engineers. As institutions and educators continue to innovate in this space, they should focus on creating sustainable partnerships, designing meaningful projects, and fostering inclusive environments that empower students to thrive.

Future Directions

Moving forward, this research can inform broader discussions on the scalability and institutionalization of ICC practices. Future work should explore:

- Longitudinal impacts of ICC training on students' academic and professional trajectories.
- The role of community voices in co-creating engagement projects and shaping learning outcomes.
- Strategies for embedding ICC into curricula beyond engineering, promoting interdisciplinarity in community engagement.

In conclusion, ICC training is not merely an add-on to engineering education; it is a critical tool for fostering a generation of engineers capable of engaging with the world's most pressing challenges. By centering cultural awareness and inclusion in educational practices, we can create a more equitable, innovative, and impactful engineering profession.

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