Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025
Paper ID #47669

Enhancing Teachers’ Intercultural Awareness and Understanding of Human Centered Design through a Unique Research Experience for Teachers

Margaret Pinnell, University of Dayton
Dr. Leanne Petry, Central State University

Dr. Leanne Petry is a Materials Engineer and Professor in the College of Engineering, Science, Technology, and Agriculture (CESTA) at Central State University (CSU). Her expertise lies in analytical and materials characterization techniques, including microscopy, spectroscopy, chromatography, and electrochemistry. Her research focuses on electrode surface oxidation-reduction reactions for sensor applications, material corrosion mechanisms, and electrochemical degradation. She is a strong advocate for integrating high-impact practices, such as problem-based learning, into lectures, laboratories, and outreach initiatives to enhance student and community engagement in STEM education.

Elizabeth Generas, Wright State University

Elizabeth Generas is an external evaluator for education and social justice projects. She completed a graduate certificate in Program Evaluation from Wright State University, where she is also a doctoral candidate in the Doctor of Organization Studies program.

Dr. Amy Anderson

Amy Anderson is the Associate Provost for Global and Intercultural Affairs and Executive Director of the Center for International Programs (CIP) at the University of Dayton. The CIP provides coordination, strategic planning and administrative support for

Mrs. Marjorie Langston Langston
Mr. Douglas Picard, Greene County Career Center

Doug Picard is an engineering and manufacturing instructor at the Greene County Career Center in Xenia, Ohio. In 2023 and 2024, he participated in the Global STEM RET, facilitated by University of Dayton and Central State University, with in- and pre-service teachers from Dayton and surrounding area. He traveled to Banagalore, India, to observe and research how solar and other renewable energies are incorporated into developing areas and developed/published classroom curriculum. As part of this research experience, he earned the Global Competence Certificate through AFS. He has participated in manufacturing externships through the Ohio STEM Learning Network and Battelle, and has brought grant-funded human-centered design resources/projects to his program. His program graduates have a 90% retention rate in manufacturing and engineering related job placements and college enrollments. Prior to entering the teaching industry, Doug served in the United States Air Force for 21 years. In this career, he developed test programs, equipment, and installation/maintenance procedures for avionics, radar, and electronic countermeasures systems in the E3B AWACS and B1B Lancer. He also taught electronic principles, avionics/radar/electronic countermeasures, theory, and logistics/supply chain to first term airmen and international students for five of those years as a master instructor. His career culminated in working on the Headquarters Air Force Material Command staff as a policy writer and subject matter expert for the engineering and logistics directorate. In this six year-long position he co-created an centralized enterprise logistics dashboard and Department of the Air Force level policy for avionics technology resource management and visibility.

Camryn Lanise Justice, University of Dayton

Enhancing Teachers' Intercultural Awareness and Understanding of Human Centered Design through a Unique Research Experience for Teachers

Introduction

In 2019, the University of Dayton (UD) and Central State University (CSU) received a three-year collaborative National Science Foundation Research Experience for Teachers (NSF RET) grant entitled *Global STEM - Appropriate Technology for Developing Communities* (Global STEM). The overarching objective of this grant was to provide a transformative community engaged engineering research and design experience for current and future teachers that increased their intercultural awareness and exposed them to the integrative nature of engineering and the social impact that engineering has on our world. The community engaged engineering and research experiences were thematically centered on human-centered design and appropriate technology for emerging economies.

This professional learning experience for teachers was intended to provide the teachers with the tools and knowledge to foster more inclusive STEM classrooms where all students have equitable access to STEM education and inspiration. The rationale for the focus of this project stems from two key needs: (1) the well-documented necessity for increased diversity and participation in STEM fields, especially engineering, and (2) the imperative for teachers to develop intercultural competence to effectively educate an increasingly diverse K-12 student body.

A community engaged learning (CEL) approach was taken in this project based on the work of Farinde, Tempest and Merriweather (2014) who report that careers with perceived high levels of community engagement may be more attractive to African American, Latino/Latina, Native American and females. CEL in STEM has been found to be highly effective at helping participants understand how STEM careers, particularly engineering, can have a high level of community engagement, can be used to help humanity, require creativity and can be a highly personally rewarding career (Ferinde, Tempest & Merriwether, 2014, Zarske, Schnee, Bielefeldt & Reamon, 2013, Committee on Public Understanding of Engineering Messages, National Academy of Engineering, 2008, Swan, Peterson & Bielefeldt, 2014). Furthermore, Zarske, et al. (2013) found that project-based service-learning design experiences significantly impact the identity and self-efficacy of women and minority students when compared to Caucasian males. In addition to these educational benefits, CEL is also effective in developing the intercultural competence of the participants (Campus Compact, 2017 Palpacuer-Lee & Curtis, 2017, Walters &Nwagwu, 2019).

Creating Equitable and Inclusive STEM Classrooms

It is well established that a strong and diverse Science, Technology, Engineering and Mathematics (STEM) workforce is critical to the United States (US) economy, national security and the health and well-being of our nation and world. STEM professionals drive innovation and technological advancements that fuel economic growth and global competitiveness and address critical issues such as climate change, prevention and treatment of disease, and access to clean drinking water, among others. (Brahm, 2021, Cummings, Wells & Trump, 2024, National Science Board (NSB), National Science Foundation (NSF), 2021, Sorensen, 2021). For example, STEM jobs support approximately 70% of the US Gross Domestic Product (GDP), contribute approximately $2.3 trillion in annual federal tax revenue and generate high-earning potential (Cogent Infotech, 2024; Consortium of Social Science Associations, 2023). STEM professionals are essential to advancing technological and defense system superiority and addressing complex global challenges that threaten national safety and security (Brahm, 2021). Further, they play a crucial role in developing innovative solutions to public health challenges as exemplified during the COVID-19 pandemic where STEM professionals designed and distributed personal protective equipment and vaccines and made significant advancements in telemedicine, predictive models and diagnostic tests (Braund, 2021, Fork & Koningstein, 2021).

Unfortunately, the US is falling behind in STEM fields, a trend exacerbated by equity gaps in K-12 and higher education. The US no longer leads in science and engineering research publications or patents, and it graduates fewer STEM Ph.D.'s compared to countries like China (National Science Board, National Science Foundation, 2021, Zwetsloot, et al, 2021). These gaps begin early, with significant disparities in STEM education outcomes among students of different races and socioeconomic backgrounds. For instance, only 81% of African American, and 83% Hispanic students graduate high school on time, compared to 90% of white students (National Center for Education Statistics, 2024). These disparities continue into higher education, affecting the diversity and talent pool in STEM fields. The implications of this are profound as diversity in the STEM workforce is essential for fostering innovation and driving economic growth. A diverse workforce brings a wide range of perspectives, ideas, and problem-solving approaches, which can lead to more creative and effective solutions to complex problems (Jones, Chirino & Wright, 2020, Madhi & Hudin, 2020, Solheim, 2022, NSF, 2024). According to the National Science Foundation, diversity is America's unique advantage in science and technology, as it leverages different backgrounds, experiences, and viewpoints to enhance problem-solving and discovery (National Center for Science and Engineering Statistics, 2023). Additionally, STEM jobs are associated with higher wages and lower unemployment rates, making equal access to these opportunities crucial for economic equity. Therefore, addressing these equity gaps is crucial for ensuring the U.S. remains a global leader in STEM and maintains its economic and security advantages (Brahm, 2021, Madhi & Salleh, 2021, National Science Board, National Science Foundation, 2021).

Increasing the number of students interested in and academically prepared for STEM, particularly those from underrepresented or underserved groups, is a complex and multifaceted challenge. This challenge encompasses external factors such as access to educational opportunities, quality instruction, and advanced coursework, as well as intrinsic psychological factors such as identity, self-efficacy, sense of belonging, and value perception (Allen, 2022; Anderson & Ward, 2014; Collins, 2018; Kricorian, Seu, Lopez, Ureta & Equils, 2020; Jackson, Mohr-Schroeder, Bush, Maiorca, Roberts, Yost & Fowler, 2021). The interconnected external and intrinsic factors shaping a student's interest in and preparedness for STEM careers are influenced by multiple aspects of the student's identity and life, as well as entrenched cultural, racial, and gender stereotypes related to STEM and perceptions of who can succeed in these fields (Allen, 2022; Bryan & Allexsaht-Snider, 2008; Farinde & Lewis, 2012; Killpack & Melon, 2016; Tytler, 2014). Educational inequities further complicate this issue, as disparities in school funding, quality of instruction, and availability of advanced coursework disproportionately affect students from marginalized communities (Coley, et al, 2024). Addressing these inequities is essential to fostering a more inclusive and diverse STEM workforce.

In addition to providing the academic preparation students need to be successful in STEM, teachers play a significant role in helping students develop an awareness of and interest in different STEM career opportunities (Maltese, Melki & Wiebke, 2014; Vedder-Weiss & Fortus, 2012). Further teachers impact student's self-efficacy, STEM identity, sense of belonging, and outcome expectations which can influence the student's choice to pursue STEM courses and careers (Allen, 2022; Bryan & Guzey, 2020; deBrey, Musu, McFarland, Wilkinson-Flicker, Diliberti, Zhang, Branstetter & Want, 2018; Tytler, 2014). However, integrating STEM into classrooms poses significant challenges for many teachers. These challenges range from the necessity of adapting pedagogical approaches to fit STEM instruction, to facing curricular limitations and structural obstacles within schools, such as rigid class schedules and insufficient administrative and financial backing. Some teachers have low self-efficacy related to STEM content or career knowledge, making them hesitant to integrate STEM into their classrooms. Teachers also encounter student-related hurdles, such as a lack of interest or confidence in STEM subjects (Bryan & Guzey, 2020; Margot & Kettler, 2019). These barriers collectively hinder teachers' ability to effectively introduce and engage students in STEM, ultimately impacting the students' exposure, interest, and preparation in these vital fields.

These barriers and challenges are compounded by the fact that teachers have biases and stereotypes at the same level as the rest of the American population. These biases can significantly impact student engagement and career choices. Research has shown that biases and stereotypes held by teachers can influence their recommendations for students' career tracks. For example, teachers may unconsciously view certain occupations as "more masculine" or "more feminine," which can steer students toward or away from specific fields. This can lead to gender imbalances in fields like STEM, where female students are often underrepresented. Additionally, teacher biases can affect students' academic performance and self-esteem, further influencing their career aspirations. Therefore, addressing these biases through awareness and training is crucial for creating a more equitable educational environment (Allen, 2022; Carlana, 2022, de Brey, Musu, McFarland, Wilkinson-Flicker, Diliberti, Zhang, Branstetter & Wang, 2019; Starck, Riddle, Sinclair & Warikoo, 2020, Varthana, 2023).

Classroom bias is particularly concerning considering the changing demographics of the US which will lead to even more diverse classrooms in our schools (Passel & Cohn, 2008). If the US is to reestablish itself as a leader in STEM and meet future workforce needs, it needs to ensure that all students are inspired in STEM, that equity gaps are closed with regard to students' access to high-quality STEM experiences, and that the nation taps into the innovation, creativity, and brilliance that can only be realized through diversity of thought and perspectives (Allen, 2022; Jones, 2020; National Center for Science and Engineering Statistics [NCSES], 2023). This can only be achieved if teachers are provided with opportunities to increase their cultural competence allowing them to address implicit bias and stereotypes in their classrooms (Howard, Overstreet, & Ticknor, 2020; DeJaeghere & Cao, 2009).

Increasing cultural competence in teachers is crucial to fostering an inclusive and effective learning environment. When teachers understand and appreciate the diverse cultural backgrounds of their students, they can create a classroom atmosphere where all students feel valued and respected. This not only enhances student engagement and academic outcomes but also promotes social cohesion and prepares students for a globalized world. According to Hammer (2015), intercultural competence is defined as "the capability to shift one's cultural perspective and appropriately adapt behavior to cultural differences and commonalities" (p. 483). Teachers who possess a high level of intercultural competence adopt an asset-based approach towards cultural differences (Pierre, Rathee, & Rathee, 2021). Okken et al. (2015) identify three key competencies of intercultural competence for teachers: foundational, facilitation, and curriculum design. These competencies encompass behaviors such as openness, social initiative, differentiation, communication skills, student-centered learning, creativity, and classroom management (Okken, Jansen, Hofman, & Coelen, 2022). If teachers are provided the opportunity to enhance their cultural competence and STEM knowledge and awareness, they can more equitably teach and inspire a more diverse student body to consider STEM as a viable career path (Jackson, Mohr-Schroeder, Bush, Maiorca, Roberts, Yost, & Fowler, 2021, Tehee, Isaacs, & Domenech Rodríguez, 2020).

Professional Learning for Teachers

As discussed above, in order to grow a diverse STEM workforce, teachers need to develop a better understanding of STEM careers, concepts and pedagogical strategies as well as develop their cultural competence to create more inclusive classrooms. There have been concentrated efforts over the past several decades to improve teachers' skills and confidence in teaching STEM subjects. One longstanding effort is the National Science Foundation's Research Experience for Teacher's program which started in the 1990's. This program provides grant funding to colleges, universities and other organizations that expose the teachers to authentic, hands-on research and engineering experiences under the mentorship and guidance of a faculty member or researcher. The goals of the NSF RET program are to provide teachers with STEM insights and practical knowledge that they can bring back to their classrooms, enriching their teaching and inspiring their students. The RET program also aims to foster long-term collaborations among universities, community colleges, school districts, and industry partners, creating mutually beneficial partnerships to help the teachers develop a deeper understanding of STEM content and pedagogy (NSF, 2024b). Teachers who participate in RET programs report increased confidence in their teaching abilities, a better understanding of the engineering design process, and an enhanced ability to integrate real-world applications into their lessons. Additionally, these programs often lead to the development of professional networks and support systems that are invaluable for ongoing professional growth. As a result, RET programs not only improve teachers' content knowledge but also their pedagogical skills, ultimately benefiting their students' learning experiences and outcomes (Bowen, Shume & Kellmeyer, 2021, Margot, & Kettler, 2019, Sungur, Saylan, Ates & Garzon, 2023, Klein-Gardner, Johnston & Benson, 2012, Pop, Dixon & Hogue, 2020, Nichol, Crawford, Barr & Cerda, 2021).

Several strategies have been employed to help current and future teachers develop their intercultural competence, with mixed results. These strategies include professional development workshops based on multicultural education theories and culturally supportive teaching, as well as short-term (2-3 weeks) and long-term (4 months to 1 year) teacher exchange or study abroad programs (Cushner & Chang, 2015; Okken, Jansen, Hoffman, & Coelen, 2022; He, Lundgren, & Pynes, 2017; Charity Hudley & Mallinson, 2017). Cushner and Chang (2015) utilized the Intercultural Development Inventory (IDI) to study the effectiveness of eight to fifteen-week international student teaching programs. Although they observed some growth in intercultural competence, the change was not significant. He, Lundgren, and Pynes (2017) described a program for experienced teachers that included a pre-departure course, a four-week program in China, and a follow-up curriculum design activity. While they also noted only modest growth on the IDI, participants showed positive changes in beliefs, insights, and teaching practices. In contrast, Okken, Jansen, Hoffman, and Coelen (2022) found that international experiences significantly enhanced teachers' intercultural competence using different assessment strategies. Similarly, Charity Hudley and Mallinson (2017) reported that their professional development workshops effectively improved teachers' intercultural competence.

Community Engaged Learning to Promote Intercultural Competence and STEM Interest

Community Engaged Learning (CEL) is a powerful pedagogical tool that has been found to have numerous educational benefits (Campus Compact, 2017 Palpacuer-Lee & Curtis, 2017, Walters & Nwagwu, 2019). Natarajarathinam, Qiu, and Lu (2021) conducted a systematic review that analyzed studies on CEL programs in engineering education from 1980-2019. Their findings highlight the positive impact of CEL on participants' understanding of engineering's societal impact, increased interest in engineering careers, and enhanced cultural competence. Similarly, in a study conducted by Goggins and Hajdukiewicz (2022) on the impact of 300 CEL engineering projects, they found that engagement in these projects helped participants recognize the long-term value of engaging with community partners, understand their future role as engineers, and develop cultural competence. In a book chapter by Swan and Bielefeldt (2015), the authors discuss the rapid increase in local and global CEL experiences in engineering education. This chapter highlights the positive impacts on student attitudes and identity, as well as the development of cultural competence through engagement with diverse communities. Mathais & Madhavan (2023) discuss how CEL in engineering can deepen understanding between engineers and communities and improve the impacts of engineering projects. It also emphasizes the need for engineers to engage with communities in human-centered design to avoid unintended negative consequences.

Program Description

The objectives of the Global STEM project were that over a three-year period, 36 current and future teachers would:

(1) Transfer applied engineering design and research activities to their classrooms and develop and disseminate new curricular or learning modules associated with these activities.
(2) Attain new knowledge of engineering disciplines and careers, have a deeper understanding of how engineering can be used to serve the local and global community, and gain a new appreciation for the value of diverse team-based learning environments.
(3) Develop greater intercultural self-awareness and an understanding of how cultural norms affect engineering design and the adoption of engineering innovations.
(4) Along with university research mentors, benefit professionally through development activities integrated in the RET programming.

The Global STEM program welcomed its first cohort in 2019, pausing for two years because of travel and other restrictions due to the COVID-19 pandemic. The first cohort completed their immersion in 2022, and the second and third cohorts completed theirs in 2023 and 2024, respectively. The Global STEM program had five distinct components: (1) Intercultural competence and travel preparation; (2) Appropriate technology related research and/or human-centered design that supports the work of an international community partner under the mentorship of a faculty member at one of two regional universities; (3) On-site work at the international community partner's facility; (4) Two-week intensive curriculum development with the participant cohort under the guidance of a curriculum coach; and (5) Follow-on programming that includes continued research with a faculty member as well as piloting, revising, and final submission of curriculum to TeachEngineering. In the final year, an intensive research week was added to the program to enhance the participant's exposure to human-centered design.

Although the specific schedule varied with each cohort, participants were recruited in the fall and engaged in monthly half- to full-day orientation and professional learning sessions January through May. In order to ensure that this program employed research based best practices related to international immersions and fair-trade learning, it partnered with Greene County Career Center to develop and facilitate participant pre-departure sessions that included cultural orientation, intercultural competence development sessions, health, safety and travel information and technical preparation (Hargman, Paris, & Blache-Cohen, 2014; Lough & Toms, 2018). Additionally, Cohorts 2 and 3 participants and program facilitators engaged in the Global Up Global Competence Certificate (GCC) online learning opportunity offered through AFS Intercultural Programs (https://afs.org/Certificate) before, during and after the participants' two to three-week international or domestic immersion. All the technical preparation was centered around concepts of human-centered design and appropriate technology. Cohorts 1 and 2 engaged with their faculty mentors on engineering design and research experiences related to the United Nations Sustainable Development Goals (https://sdgs.un.org/goals) that aligned with the work of their community partner placements before and after their immersion. Based on feedback provided by the participants, an adjustment was made for Cohort 3 where the participants were exposed to multiple different human-centered design and research experiences with faculty mentors through activities facilitated during the pre-departure and follow-on professional learning sessions. Further, an intensive Research Week was added for Cohort 3 where the participants were engaged in additional human-centered engineering design and research experiences hosted at both university campuses as well as at the Greene County Career Center.

In late June to early July, the Global STEM participants engaged in their international or domestic immersion with their community partner for two to three weeks. For Cohorts 1 and 2, the participants traveled internationally or domestically individually or in small groups to their assigned community partner sites for two to three weeks, where they engaged in engineering research and design activities. Cohort 3 participants travelled as a large group to a single site where they engaged with their community partner for three weeks.

Upon their return, the participants engaged in an intensive, two-week curriculum development workshop under the guidance of a curriculum coach. During the school year, the in-service teachers piloted their curriculum in their classroom and worked with the curriculum coach to revise, edit and submit their curriculum for publication to TeachEngineering. Further, Cohorts 1 and 2 participants continued to engage with their faculty mentors, and Cohort 3 engaged in facilitated human-centered engineering design and research experiences and activities. The program concluded with participants providing oral and poster presentations to summarize their engineering and intercultural experiences as well as how they brought these experiences back to the classroom through the development of curriculum and activities.

Participants:

Over the course of the three-year program a total of 31 teachers and pre-service teachers engaged in the program as shown in Table 1.

Table 1 - PROGRAM NAME Participant Placements

Partner Organization	Location	Engineering Project	Number of Participants	Year(s)
Etta Projects	Bolivia	Engineering design of dry, ecological bathrooms, and use of medicinal plants, and aquaponics.	2	2023
United Rehabilitation Services	Dayton (US)	Analysis and use assessment of assistive and educational devices.	1	2023
Alhassan Foundation	Egypt	Design of personalized wheelchairs for differently abled persons.	2	2023
Academic City	Ghana	Sustainable engineering design for waste management using laser printing and 3D printing	4	2023
SELCO Foundation	India	Engineering solutions for energy independence to improve health and livelihood in marginalized communities.	4	2022 and 2023
Vision Empower	India	Engineering a prototype for visually impaired students to understand shapes and line changes.	2	2022
Commission to Every Nation	Guatemala	Engineering sustainable robotics for enhancing agriculture	1	2022
Burn Design Lab	Washington (US)	Manufacturing efficient cookstoves for use in Africa	1	2023
Tandana Foundation	Ecuador	Designing agricultural and hydraulic projects alongside facilitating STEM lessons in community schools	14	2024

Methods:

A convergent parallel mixed method (Creswell & Plano, 2007) was the research design of choice for the evaluation as it meets the Joint Committee on Standards for Educational Evaluation (Yarbrough, Shula, Hopson, & Caruthers, 2010). Quantitative and qualitative data were collected during each year and weighted equally. The two data types collected documented and assessed successes and challenges for each cohort.

Quantitative assessment data from the Intercultural Development Inventory (IDI) and Intercultural Effectiveness Scale (IES) were analyzed as matched pair t-tests to determine if there were any significant differences in pre- and post-data. Cohort 1 had a two-year gap between the pre and post assessments due to the pause from COVID-19 from March 2020 to 2022. Cohorts 2 and 3 participants completed both the IDI and the IES at the start of the program in January and then again in July after returning from their immersion.

The IDI is a statistically reliable and cross-culturally valid measure of intercultural competence. It is a 50-item questionnaire with responses to statements made on a five-point agree-disagree scale. It has been psychometrically tested and determined to be a robust cross-culturally generalizable, valid and reliable assessment of an individual's or group's core orientations toward cultural difference (Hammer, 1999, 2007, 2009; Hammer et al., 2003; Paige, Jacobs-Cassuto, Yershova, & DeJaeghere, 2003). Validation of the IDI is based on confirmatory factor analysis, reliability analysis, and construct validity tests. The IDI offers three measures. The first is the Perceived Orientation (PO), or where an individual believes they fall on the continuum. The second is the Developmental Orientation (DO), or where the individual's answers on the IDI indicate where they actually are on the developmental continuum, Figure 1. The difference between these two numbers is called the Orientation Gap (OG).

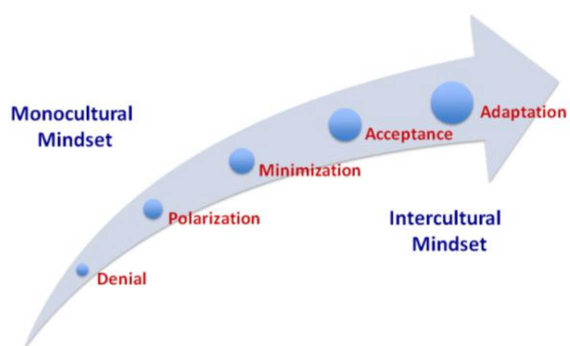

Figure 1. IDI developmental continuum.

The IES was developed and validated to measure an individual's behavioral ability or intercultural effectiveness in intercultural interaction. Based on a review of global leadership competencies, the IES is used in contexts such as those found in many educational settings, where economy and ease of administration are critical program elements. The IES (Mendenhall, Stevens, Bird, Oddou & Osland, 2011) consists of three domains: Continuous Learning, Interpersonal Engagement, and Hardiness. Each of these competencies can be broken down into sub-competencies, which are important aspects of intercultural competency. Factor analysis for each subscore grouping resulted in a coefficient alpha reliability of between 0.79 to 0.84 (Mendenhall, Stevens, Bird, Oddou & Osland, 2008).

Qualitative audio data from surveys and interviews were collected throughout the year. Participant interviews were transcribed and coded using a constant comparative analysis (Guba & Lincoln, 1994) based on themes predetermined according to project objectives as well as themes that emerged during the analyses, such as online resources, content usefulness, time commitment, and activities in class. Similar analyses were implemented for the participant online surveys. Trustworthiness methods (Shenton, 2004) were included in the analyses such as member checks, literature reviews, research journal entries, and triangulation to limit any aspects of biases during the analyses. Questions for surveys and the interview were developed collaboratively with the RET program team.

Results and Discussion:

The Global STEM project was successful in providing 27 teachers with a transformative summer experience(s) centered on human-centered design and appropriate technology for economically developing countries. Four teachers participated in the program multiple years, taking leadership roles later in the program. Thirteen lessons were successfully co-designed, piloted, and submitted to TeachEngineering, adding to the body engineering lessons available for other educators. All the lessons focused on human-centered design related activities, and many of these lessons included an international component. Further, most of the participants had not heard of the United Nations’ Sustainable Development Goals (SDG) prior to participating in this RET. After learning of the SDGs, many participants incorporated one or more of the SDGs in their lesson development. Similarly, upon returning from the immersion experience, many participants reported a new understanding of the social impact of engineering. For example, participants commented:

Because, I mean, if I can take what I've learned, and what I've gathered, not just about culture, but how engineering, you know, it can be practical and not just, you know, the latest and greatest, but how we can take simple stuff and have a huge impact on the lives of people.

The main focus of the engineering we saw was making it accessible… Materials needed to be fairly cheap and little impact on the environment.

I think seeing how the projects [the community partner] are involved with changed people’s lives for the better, gave me a better understanding of how beneficial the engineering process is. Electricity is something we don't really think about, you flip the switch and the lights are on, but that is not the case everywhere so seeing how community's [sic] do without or how *community's [sic] use the solar to enhance their livelihoods is what the [community partnership] was about.*

A total of 635 students were part of the pilot lessons in participants' classrooms from 18 different schools. Two-thirds of the schools where RET participants worked and/or piloted the lessons had more than 50% of the student population eligible for free or reduced lunch. One-third of the schools had populations of underrepresented students of 50% or more. Classrooms ranged from 4th grade to 12th grade and included STEM fields, like science, biotechnology, and robotics, as well as English and Spanish. RET participants noted high student engagement in the classrooms where lessons were piloted. One participant commented:

> "*They really enjoyed it. The kids love the cultural component of lessons like that, because then they can learn about different groups of people. So if you have kids that really aren't interested in science, but they're interested in more of the humanities, then you can kind of grab more of your population and get them interested and hooked*".

Although a direct correlation can not be made at this time, the observed high level of student engagement with the STEM lessons developed and piloted during this RET align with the findings in the literature that activities with a high level of community engagement that show how engineering can be used to help humanity are more appealing to a diverse group of students (Ferinde, Tempest & Merriwether, 2014, Zarske, Schnee, Bielefeldt & Reamon, 2013, Committee on Public Understanding of Engineering Messages, National Academy of Engineering, 2008, Swan, Peterson & Bielefeldt, 2014).

As described above, the IDI provides three quantitative measures to assess an individual's or groups' core orientation towards cultural difference. Outcomes from the IDI varied among the cohorts. Given the unique make-up of each cohort combined with significant changes made to the programming and implementation of the experience, this difference is not surprising. The overall average PO and DO scores increased and the OG decreased, as expected. However, the average scores were found to fall within the same developmental orientation of Acceptance and Minimization, respectively. As shown in Table 2, the p-value for changes in pre to post IDI scores for Cohorts 1 and 2 do not represent a significant difference ($p < 0.05$: statistically significant). However, the changes in the PO and DO scores for Cohort 2 represent a significant difference.

Table 2 – P-Value for changes in Pre/Post IDI scores

	PO	**DO**	**OG**
Cohort 1	0.258	0.400	0.592
Cohort 2	0.034	0.006	0.091
Cohort 3	0.734	0.561	0.848

Individually, some shifts occurred in the IDI scores in each cohort. For Cohort 1, of the five individuals who completed the program after the pause due to COVID-19, the IDI scores for three participants did shift developmental levels. One participant went from a PO in Acceptance and DO in Minimization to a PO in Adaptation and a DO in Acceptance. This represents an important intercultural developmental advance. Another participant experienced a shift in their PO from Acceptance to Adaptation indicating a stronger desire or goal toward intercultural competence. A third participant experienced a DO from minimization to polarization, indicating a developmental regression. Of the eleven individuals who completed the program for Cohort 2, the IDI scores for four participants shifted developmental levels. Three of those increased from polarization to minimization, denial to polarization, and minimization to acceptance, respectively. One participant's developmental level decreased from acceptance to minimization. This same participant's perceived orientation also decreased one level from adaptation to acceptance. It is not uncommon for individuals who experience a developing economic environment for the first time, to look more critically at their culture and experience polarization as reversal. Of the twelve individuals from Cohort 3 who completed the program and took both the pre- and post-assessment, the IDI scores for four participants shifted Developmental Orientations. Three participants moved forward to a developmental level with one participant each moving from denial to polarization, from polarization to minimization, and from minimization to acceptance. One participant's developmental level decreased from acceptance to minimization.

Table 3 – Percentage of participants in each cohort that experienced developmental regression, advancement of whose developmental level was unchanged.

	Decreased IDI Level	**Remained the Same**	**Increased IDI Level**
Cohort 1	20%	40%	40%
Cohort 2	9%	64%	27%
Cohort 3	8%	67%	25%

Results from the IES also varied across cohorts, Tables 4 and 5. For Cohort 1, the matched-pairs analysis indicates there were significant differences ($p < 0.05$: statistically significant) in overall intercultural effectiveness, and on each of the three domains. The only sub-competency that did now show significant difference between pre and post was in World Orientation, or the degree to which one is interested in other cultures and the people who live in them. World orientation was the lowest sub-competency in the pre-test results. However, the overall domain of Interpersonal Engagement reflected significant growth due to strong gains in Relationship Development.

For Cohort 2, there were increases in each of the domains and sub-competencies, however, the only domain that indicates a significant difference between pre and post was in Continuous Learning, or how we learn about people and the accuracy of that learning. Continuous Learning has two sub-competencies. For Cohort 3, there were no significant difference between pre and post for any domain or sub-competency.

Table 4 – P-Value for changes in Pre/Post IES results.

	Cohort 1	**Cohort 2**	**Cohort 3**
Continuous Learning	0.020	0.031	0.971
Self-Awareness	0.024	0.057	0.219
Exploration	0.019	0.056	0.525
Interpersonal Engagement	0.029	0.300	0.813
World Orientation	0.119	0.549	0.406
Relationship Development	0.015	0.140	0.337
Hardiness	0.013	0.144	0.488
Positive Regard	0.005	0.096	0.994
Emotional Resilience	0.044	0.434	0.533
Overall IES	0.016	0.071	0.859

As shown in Table 5, the pre- program IES scores for cohort 3 were the highest among the cohorts indicating that the Cohort 3 participants came into the program with a strong ability to navigate and adapt to different cultural contexts. Cohort 1 had the lowest pre-program IES result and experienced the greatest amount of growth.

Table 5 – RET Participant Pre/Post IES results.

	Pre	Post	Change	P-Value
Cohort 1	3.74	5.20	1.45	0.016
Cohort 2	5.14	5.51	0.37	0.071
Cohort 3	5.35	5.38	0.03	0.859

Participant comments regarding personal development included:

I always felt like you know, I'm a minority, I didn't have that much room to grow. But I do. That's what those skills taught me.

The most impactful thing about completing the GCC modules and the discussions is realizing how I have never been in a situation where I am the minority. It has given me a greater drive to understand what others go through. It has also made me realize that I will be put in those situations during my travel and I am feeling better equipped to deal with that.

The experience and my mindset has changed and, just, open to trying new things, because I'm that person that if I go to a restaurant and I've never ate there before, I'm getting, like, a hamburger French fries. But now I'm open to actually trying different things. It was my first time out of the country.

As mentioned, significant programmatic changes were made for each cohort based on feedback from the evaluator, facilitator and participants. For example, the GCC was added for Cohorts 2 and 3, but was not part of the experience for Cohort 1. Cohort 3 travelled as a large group to a single immersion site, whereas Cohorts 1 and 2 travelled in small groups of two to four participants to multiple immersion sites. Finally, Cohort 1 was impacted by COVID 19 which created a two year pause in their experience. Similarly, the make-up of each cohort was impacted by individual personalities, prior experiences, varying levels of intercultural competence coming into the program (Table 5), and group dynamics. These confounding factors make it challenging to develop conclusions regarding the impact of the RET experience on the cultural competence of the participants. This observation aligns with the mixed results reported in the literature on the efficacy of various strategies to develop the cultural competence of teachers. For example, Cushner and Chang (2015) utilized the Intercultural Development Inventory (IDI) to study the effectiveness of eight to fifteen-week international student teaching programs. Similar to what was found in this study, Cushner and Chang observed some growth in intercultural competence, but the change was not significant. He, Lundgren, and Pynes (2017) report similar findings for a four-week teacher immersion program in China. Conversely, Okken, Jansen, Hoffman, and Coelen (2022) found that international experiences significantly enhanced teachers' intercultural competence, however these authors used a different assessment strategy.

Conclusions:

The Global STEM project successfully provided 27 teachers with a transformative summer experience focused on human-centered design and appropriate technology for economically developing countries. With four teachers participating multiple years and assuming leadership roles, the program saw the creation and submission of thirteen co-designed lessons to TeachEngineering. These lessons, which emphasized human-centered design and often included an international aspect, significantly enriched the engineering lesson resources for other educators.

A noteworthy outcome was that many participants, unfamiliar with the United Nations' Sustainable Development Goals (SDGs) before the program, incorporated these goals into their lesson development after the immersion experience. This immersion also led to a deeper understanding of the social impact of engineering among participants. High student engagement was reported in the 635 students who participated in pilot lessons, with one teacher highlighting that the cultural components of the lessons particularly captivated students with varied interests.

The IDI results showed an overall increase in both Perceived Orientation (PO) and Developmental Orientation (DO) scores, with a decrease in the Orientation Gap (OG) across all cohorts, indicating growth in intercultural competence. However, due to the unique makeup and significant programmatic changes for each cohort, these outcomes varied. Cohort 2 showed significant improvements, while Cohorts 1 and 3 did not exhibit statistically significant changes. Individual shifts in developmental levels were observed, including advancements and regressions, reflecting the complex dynamics of intercultural competence development. The IES results increased for each cohort. However, only cohort 1 showed significant changes from pre- to post across multiple dimensions. Cohort 1 also started with a significantly lower pre IES score than the other two cohorts.

Significant programmatic adjustments, such as the addition of the GCC for Cohorts 2 and 3 and varying immersion site arrangements, along with the impacts of COVID-19 on Cohort 1, contributed to the difficulty in drawing definitive conclusions about the RET program's overall impact on the participants. This aligns with mixed findings in the literature, where some studies report modest growth in intercultural competence, while others, using different assessment methods, show significant enhancements. These findings underscore the complex and multifaceted nature of developing intercultural competence among educators.

Limitations and Future Work:

In addition to significant programmatic adjustments and project delays that impacted the data and made it difficult to draw definitive conclusions regarding program outcomes, a small sample size, and significant differences in participant experiences coming into the program were also limitations of this study.

The primary goal of this work was to provide the teachers with the tools and knowledge to foster more inclusive STEM classrooms. The study focused on the impact this program had on the participants. A follow-on study could be conducted to assess if this program also impacted the STEM interest of the students in the participants' classrooms.

Acknowledgements:

This collaborative effort NSF RET: Global STEM - Appropriate Technology for Developing Communities is supported in part by the National Science Foundation under Grant Numbers EEC-1855231 and EEC-1855239. Any opinions, findings, and conclusions or recommendations expressed herein are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References:

Allen, T. G. (2022) Young, Gifted and Missing, Diversity in Higher Education, 25, 163–181 Copyright © 2022 Tawannah G. Allen Published under exclusive license by Emerald Publishing Limited ISSN: 1479-3644/doi:10.1108/S1479-364420220000025012

Andersen, L. and Ward, T.J. (2014), Expectancy-Value Models for the STEM Persistence Plans of Ninth-Grade, High-Ability Students: A Comparison Between Black, Hispanic, and White Students. Sci. Ed., 98: 216-242. https://doi.org/10.1002/sce.21092

Brahm, J. (2021). STEM Education Should be a National Security Priority. Space Force Journal. Retrieved from https://spaceforcejournal.org/stem-education-should-be-a-national-security-priority/

Braund M. (2021). Critical STEM literacy and the COVID-19 pandemic. Can J Sci Math and Technol Educ. 21(2):339-356. doi: 10.1007/s42330-021-00150-w.

Bryan, L., & Guzey, S. S. (2020). K-12 STEM Education: An Overview of Perspectives and Considerations. Hellenic Journal of STEM Education, 1(1), 5–15. https://doi.org/10.51724/hjstemed.v1i1.5

Bryan, L., & Allexsaht-Snider, M. (2008). Community and classroom contexts for understanding nature and naturally occurring events in rural schools in Mexico. L1-Educational Studies in Language and Literature, 8(1), 43–68. https://doi.org/10.17239/L1ESLL-2008.08.01.06

Bowen, B., Shume, T., & Kallmeyer, A. (2021). Impacts of a Research Experiences for Teachers Program on Rural STEM Educators. Journal of STEM Education: Innovations and Research, 22(4), 2541-2555.

Campus Compact. (2017) GLOBALSL: Partnership for Global Learning and Cooperative Development. Retrieved on 03 September 18 from https://compact.org/global-sl/isl4/.

Carlana, M., La Ferrara, E., & Pinotti, P. (2022). Implicit stereotypes in teachers' track recommendations. AEA Papers and Proceedings, 112, 409-414.

Cogent Infotech. (2024). Diversity in STEM: How does it impact the US economy? Retrieved from https://www.cogentinfo.com/resources/diversity-in-stem-how-does-it-impact-the-us-economy.

Collins, K. H. (2018). Confronting Color-Blind STEM Talent Development: Toward a Contextual Model for Black Student STEM Identity. Journal of Advanced Academics, 29(2), 143–168. https://doi.org/10.1177/1932202X18757958.

Committee on Public Understanding of Engineering Messages, National Academy of Engineering (2008), Changing the Conversation: Messages for Improving Public Understanding of Engineering, National Academies Press, ISBN978-0-309-11934-4.

Consortium of Social Science Associations. (20230. STEM jobs' impact on U.S. GDP. Retrieved from https://www.cosssa.org/stem-jobs-impact-on-us-gdp

Coley, R. L., Carey, N., Hwang, D., Spielvogel, B., & Henry, D. (2024). Racial inequities in educational opportunity: Variation across socioeconomic status. Race and Social Problems, 16(4), 414-432. https://doi.org/10.1007/s12552-024-09415-z

Charity Hudley, A. H., & Mallinson, C. (2017). "It's worth our time": A model of culturally and linguistically supportive professional development for K-12 STEM educators. Cultural Studies of Science Education, 12, 637-660.

Creswell, J., & Plano-Clark, V. (2007). Designing and conducting mixed methods research. 2nd ed. New York: Sage.

Cummings, C.L., Wells, E.M. & Trump, B.D. (2024). Engineering and public health: converging disciplines for resilient solutions. Environ Syst Decis 44, 189–198. https://doi.org/10.1007/s10669-024-09981-y

Cushner, Kenneth & Chang, Shu-Ching. (2015). Developing intercultural competence through overseas student teaching: Checking our assumptions. Intercultural Education. 26. 1-14. 10.1080/14675986.2015.1040326.

de Brey C., Musu L., McFarland J., Wilkinson-Flicker S., Diliberti M., Zhang A., Branstetter C., Wang X. (2019). Status and trends in the education of racial and ethnic groups 2018 (NCES 2019-038). Washington, DC: National Center for Education Statistics. https://nces.ed.gov/pubs2019/2019038.pdf

DeJaeghere, J. G., & Cao, Y. (2009). Developing U.S. teachers' intercultural competence: Does professional development matter? International Journal of Intercultural Relations, 33(5), 437–447. https://doi.org/10.1016/j.ijintrel.2009.06.004

Farinde, A. A., & Lewis, C. W. (2012). The underrepresentation of African American female students in STEM fields: Implications for classroom teachers. US-China Education Review B. 4, 421-430.

Farinde, A. A., Tempest, B., & Merriweather, L. (2014). Service Learning: A Bridge to Engineering for Underrepresented Minorities. International Journal For Service Learning In Engineering, 9475-491.

Fork, D and R. Koningstein, R, (2021). How engineers can disrupt climate change,IEEE Spectrum, 58 (7), 24-29, doi: 10.1109/MSPEC.2021.9475392.

Goggins, J., & Hajdukiewicz, M. (2022). The role of community-engaged learning in engineering education for sustainable development. Sustainability, 14(13), 8208.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. Handbook of qualitative research, 2, 163-194.

Hammer, M. R. (1999). A measure of intercultural sensitivity: The intercultural development inventory. In S. M. Fowler & M. G. Mumford (Eds.) The Intercultural sourcebook (pp. 1-18). Intercultural Press.

Hammer, M. R. (2007). The intercultural development inventory manual. IDI, LLC.

Hammer, M. R. (2009). Solving problems and resolving conflict using the Intercultural Conflict Style model and Inventory. In M. A. Moodian (Ed.), Contemporary leadership and intercultural competence: Exploring the cross-cultural dynamics within organizations (pp. 219-232).

Hammer, M. R., Bennett, M.J., & Wiseman, R. (2003). Measuring intercultural sensitivity: The intercultural development inventory. International Journal of Intercultural Relations, 27(4).

Hammer, M. R. (2015). Intercultural competence development. In J. M. Bennett (Ed.), The SAGE encyclopedia of intercultural competence. Thousand Oaks, CA: SAGE Publishing, Inc, pp 483-486.

Hargman, E, Morris, C & Blache-Cohen, B. (2014). Fair Trade Learning: Ethical standards for community-engaged international volunteer tourism. Tourism and Hospitality Research, 14(1–2), 108–116. https://doi.org/10.1177/1467358414529443

He, Ye & Lundgren, Kristine & Pynes, Penelope. (2017). Impact of short-term study abroad program: Inservice teachers' development of intercultural competence and pedagogical beliefs. Teaching and Teacher Education. 66. 147-157. 10.1016/j.tate.2017.04.012.

Howard, C. M., Overstreet, M. H., & Ticknor, A. S. (2020). Engaging Preservice Teachers with Culturally Responsive Pedagogy: Three Model Lessons for Teacher Educators. Journal of Language and Literacy Education: Take 2. http://jolle.coe.uga.edu/take-2/

Jackson, C., Mohr-Schroeder, M. J., Bush, S. B., Maiorca, C., Roberts, T., Yost, C., & Fowler, A. (2021). Equity-oriented conceptual framework for K-12 STEM literacy. International Journal of STEM Education, 8, 1-16.

Jones, Graham, Chace, Bernardita and Wright, Justin. (2020). Cultural diversity drives innovation: empowering teams for success. International Journal of Innovation Science. 12. 323-343. 10.1108/IJIS-04-2020-0042.

Killpack T. & Melón L. (2016). Toward Inclusive STEM Classrooms: What Personal Role Do Faculty Play? CBE Life Sci Educ. 2016 fall;15(3):es3. doi: 10.1187/cbe.16-01-0020. PMID: 27496362; PMCID: PMC5008899.

Klein-Gardner, S. S., Johnston, M. E., & Benson, L. (2012). Impact of RET Teacher-Developed Curriculum Units on Classroom Experiences for Teachers and Students. Journal of Pre-College Engineering Education Research (J-PEER), 2(2), Article 4. https://doi.org/10.5703/1288284314868

Kricorian, K., Seu, M., Lopez, D., Ureta, E. & Equils, O. Factors influencing participation of underrepresented students in STEM fields: matched mentors and mindsets. IJ STEM Ed 7, 16 (2020). https://doi.org/10.1186/s40594-020-00219-2

Lough, B. & Toms, C. (2018) Global service-learning in institutions of higher education: concerns from a community of practice, Globalisation, Societies and Education, 16:1, 66-77, DOI: 10.1080/14767724.2017.1356705

Madhi, H. M., & Salleh Hudin, N. (2021). The impact of diversity on innovation: Literature review. International Journal of Social Science and Economic Research, 6(12), 320-330. Retrieved from https://doi.org/10.46609/IJSSER.2021.v06i12.010

Maltese, A. V., Melki, C. S. & Wiebke, H. L. (2014). The nature of experiences responsible for the generation and maintenance of interest in STEM. Science Education, 98, 937–962. https://doi.org/10.1002/sce.21132

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. International Journal of STEM Education, 6(2), 2-15.

Mathias, M., & Madhavan, G. (2023). Invisible Bridges: Why Community Engagement (Still) Matters. The Bridge, 53(4), 305179.

Mendenhall, M. E., Stevens, M. J., Bird, A. L. L. A. N., Oddou, G. R., & Osland, J. S. (2011). Intercultural effectiveness scale: Technical report. Chesterfield: The Kozai Group Inc.

Natarajarathinam, M., Qiu, S., & Lu, W. (2021). Community engagement in engineering education: A systematic literature review. Journal of Engineering Education, 110(2), 10.1002/jee.20424.

National Center for Science and Engineering Statistics (NCSES). 2023. Diversity and STEM: Women, Minorities, and Persons with Disabilities 2023. Special Report NSF 23-315. Alexandria, VA: National Science Foundation. Available at https://ncses.nsf.gov/wmpd.

National Center for Education Statistics. (2024). High School Graduation Rates. Condition of Education. U.S. Department of Education, Institute of Education Sciences. Retrieved 08 Dec 24 from https://nces.ed.gov/programs/coe/indicator/coi.

National Center for Science and Engineering Statistics (NCSES). 2023. Diversity and STEM: Women, Minorities, and Persons with Disabilities 2023. Special Report NSF 23-315. Alexandria, VA: National Science Foundation. Available at https://ncses.nsf.gov/wmpd.

National Science Board, National Science Foundation. (2021). The STEM Labor Force of Today: Scientists, Engineers and Skilled Technical Workers. Science and Engineering Indicators 2022. NSB-2021-2. Alexandria, VA. Available at https://ncses.nsf.gov/pubs/nsb20212.

National Science Foundation. (2024a). Research Experiences for Teachers (RET) in Engineering and Computer Science. Retrieved from https://new.nsf.gov/funding/opportunities/research-experiences-teachers-engineering-computer-science

National Science Foundation. (2024b). Bridging the future: Defining and empowering the STEM workforce of tomorrow. Retrieved on 10 Dec 24 from https://new.nsf.gov/funding/initiatives/ige/updates/bridging-future-defining-empowering-stem-workforce-tomorrow

Nichol, C., Crawford, C. A., Barr, C., & Cerda, I. (2021). Long-Term Outcomes of RET Programs on Female and Minority Student High School Graduation Rates and Undergraduate STEM Major Rates (Fundamental). ASEE Annual Conference proceedings, 1524-4644. https://par.nsf.gov/biblio/10295817-long-term-outcomes-ret-programs-female-minority-student-high-school-graduation-rates-undergraduate-stem-major-rates-fundamental

Okken, Grada & Jansen, Ellen P.W.A. & Hofman, W. & Coelen, Robert. (2022). Interculturally competent teachers: behavioural dimensions and the role of study abroad. Cogent Education. 9. 10.1080/2331186X.2022.2138048.

Paige, R. M., Jacobs-Cassuto, M., Yershova, Y. A., & DeJaeghere, J. (2003). Assessing intercultural sensitivity: An empirical analysis of the Hammer and Bennett Intercultural Development Inventory. International Journal of Intercultural Relations, 27(4).

Palpacuer-Lee, C., & Curtis, J. (2017). Into the Realm of Politically Incorrect: Intercultural Encounters in a Service-Learning Program. Journal of Multicultural Education. 19(2), 163-181. doi: http://dx.doi.org/10.18251/ijme.v19i2.1239.

Passel, J. S., & D'Vera Cohn, D. (2008). US population projections, 2005-2050 (p. 20). Washington, DC: Pew Research Center.

Pierre, Y., Rathee, N. K., & Rathee, V. S. (2021). Developing cross-cultural competency through multicultural perspective: An exploratory inquiry. European Scientific Journal, 17(27), 324-346.

Pop, M. M., Dixon, P., & Grove, C. M. (2010). Research Experiences for Teachers (RET): Motivation, Expectations, and Changes to Teaching Practices due to Professional Program Involvement. Journal of Science Teacher Education, 21(2), 127-147. https://doi.org/10.1007/s10972-009-9167-2

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. Education for Information, 22(2), 63-75.

Solheim, M. C. W. (2022). Diversity and inclusion is a must to make innovation work for all. Nature Index. Retrieved from https://www.nature.com/articles/d41586-022-04205-2

Sorensen, A. (2021). How engineering can contribute to a reimagining of the US public health system. The Conversation. Retrieved from https://theconversation.com/how-engineering-can-contribute-to-a-reimagining-of-the-us-public-health-system-152063

Starck, J. G., Riddle, T., Sinclair, S., & Warikoo, N. (2020). Teachers are people too: Examining the racial bias of teachers compared to other American adults. Educational Researcher, 49(4), 273–284. https://doi.org/10.3102/0013189X20912758

Sungur Gül, K., Saylan Kirmizigül, A. S., Ateş, H., & Garzón, J. (2023). Advantages and challenges of STEM education in K-12: Systematic review and research synthesis. International Journal of Research in Education and Science, 9(2), 283-307.

Swan, C., Peterson, K. & Bielefeldt, A. (2014). Community Engagement in Engineering Education as a Way to Increase Inclusiveness. In A. Johri & B (Ed.). Olds, Cambridge handbook of engineering education research, A. Johri & B. Olds. New York, NY, USA : Cambridge University Press. DOI: 10.1017/CBO9781139013451.023

Swan, K., & Bielefeldt, A. R. (2015). Community Engagement in Engineering Education as a Way to Increase Inclusiveness. In Cambridge Handbook of Engineering Education Research (pp. 357-372). Cambridge University Press.

Tehee, M., Isaacs, D., & Domenech Rodríguez, M. M. (2020). The elusive construct of cultural competence. In L. T. Benuto, F. R. Gonzalez, & J. Singer (Eds.), Handbook of cultural factors in behavioral health: A guide for the helping professional (pp. 11–24). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-030-32229-8_2

Tytler, R. (2014). Attitudes, identity, and aspirations toward science. In N. G. Lederman & S. K. Abell (Eds.), Handbook of research on science education (pp. 82–103). New York: Routledge. https://doi.org/10.4324/9780203097267.ch5

Varthana. (2023). The impact of teacher bias on student achievement. Retrieved on 09 December 2024 from https://varthana.com/school/the-impact-of-teacher-bias-on-student-achievement

Vedder-Weiss, D. & Fortus, D. (2012). Adolescents' declining motivation to learn science: A follow-up study. Journal of Research in Science Teaching, 49(9), 1057–1095. https://doi.org/10.1002/tea.21049

Walters, C., & Nwagwu, U. (2019). International Community Engagement: Transforming Students and Residents. Journal of Community Engagement and Scholarship. Retrieved on 11 December 24 from https://jces.ua.edu/international-community-engagement-transforming-students-and-residents/

Yarbrough, D.B., Shula, L.M., Hopson, R.K., Caruthers, F.A. (2010). The program evaluation standards: A guide for evaluators and evaluation users (3rd. Ed). Thousand Oaks, CA: Corwin Press.

Zarske, M.S., Schnee, D.E., Bielefeldt, A.R. & Reamon, D.T., (2013). The Impacts of Real Clients in Project-Based Service-Learning Courses, 120th ASEE Annual Conference & Exposition, ASEE, 2013.

Zwetsloot, R., Corrigan, J, Weinstein, E, Peterson, D., Gehlhaus, D., Fedasiuk. (2021). China is fast outpacing US STEM PhD growth: CSET data brief. Retrieved from https://cset.georgetown.edu/.