2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC

Host Sponsor UNC Charlotte

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #53776

RIEF: Assessing Student Engagement in a BME-focused Global Experiential Learning Program Through Application of Situated Learning Theory

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Background and Motivation

Global learning experiences effectively build global competencies in undergraduate education [1],[2],[3],[4],[5], equipping students for the global marketplace and fostering interest in international careers. In engineering, four approaches have proven effective: international collaborations, study abroad and other mobility programs, internationalization at home, and virtual collaborations [6]. These models demonstrate that meaningful global engagement is both achievable and impactful. Despite these efforts, engineering students account for only 5.7% of U.S. study abroad participants, and just 3.3% of study abroad programs are in sub-Saharan Africa [2]. This gap represents a missed opportunity given the region's rapidly growing medical technology market [7],[8],[9]. Expanding global learning opportunities is a strategic investment in preparing biomedical engineering students to innovate and compete in an increasingly globalized field.

The Biomedical Engineering Design collaboration (BMED) at Clemson University (CU) in South Carolina and Arusha Technical College (ATC) in Tanzania is a global experiential learning program centered on innovation of biomedical technologies. The partnership was formalized with a memoranda of understanding in 2015 and initial efforts between CU and ATC faculty focused on curriculum harmonization and teaching opportunities [10]. BMED was initiated to address growth in biomedical engineering jobs and meet the growing need for engineers with global skills in biomedical design to support healthcare innovation in communities with low healthcare spending [11],[12]. Over the initial five years, BMED was highly successful for engaging culturally diverse teams of students and faculty, creating international learning opportunities for engineering students at both academic institutions, and enhancing curriculum content and its delivery across intercontinental sites [10]. However, program assessment by participating faculty revealed a need to improve BMED by: 1) creating more uniform global competencies and teaching methods across partners; 2) offering more opportunities and motivation for students to build cross-cultural and practical skills in biomedical engineering design; and 3) supporting broader inclusion of underserved communities in South Carolina and Tanzania.

Project and Research Question

Our project included a research goal and a mentoring goal. Informed by our assessed needs, our **research goal** was to develop a new BMED hybrid exchange model that cultivated a design thinking mindset for innovating biomedical engineering (BME) solutions to global health problems. We used the term "hybrid exchange" because our model included both virtual and in-person global student exchange experiences to support participation and opportunity access for a broader cohort of students while developing their engineering competencies and global mindsets. Our central research question was: to what extent, and in what ways, was student engagement in an international clinically embedded BME community of practice altered by different types and levels of participation in a BME-focused global experiential learning program? Our ancillary **mentoring goal** was for the lead author to develop education research expertise with mentorship from the second author. This

material is based upon work supported by the National Science Foundation under grant number 2407457 from NSF 20-558 PFE: Research Initiation in Engineering Formation (RIEF).

Methodology

The foci of our project in Year 1 were to 1) align our program within an appropriate engineering education framework, 2) modify content of existing global health design courses by adding global health education competencies and expanding immersive experiences, 3) develop data collection instruments and interview protocols, and 4) pilot the BMED hybrid exchange model with an initial cohort of CU and ATC students. Year 2 activities are ongoing and will include two semesters of course content delivery, a second cohort of CU and ATC students, and deeper analysis of all data.

Engineering Education Framework: The BMED hybrid exchange model emphasizes learning through social interaction. Therefore, Social Cognitive (Learning) theory,[13] Cognitive Apprenticeship theory,[14] and Community of Practice theory [15],[16],[17],[18] were considered as potentially relevant theoretical frameworks. Community of Practice theory provided the most appropriate framework to guide this work because it emphasized learning and knowledge sharing as being both situational and participatory within a group that shared a common practice.

Aligned with a pragmatic paradigm, we structured our project using Situated Learning Theory (SLT) from Lave and Wenger, [16] which has been applied to design thinking [19] and study abroad [20] programs. Situated learning is a type of experiential learning that emphasizes the importance of learning within a specific context and community, where knowledge is acquired through active participation and social interaction. This theory recognizes that learning is unintentional and situated within authentic activity, context, and culture. SLT focuses on i) learning by participating in a community of practice; ii) the context and environment where learning happens; and iii) involving both novices and experts in the learning process (Figure 1). Constructs include a community of practice, novice and expert participants of the community and their relationships, and the community activities, artifacts, and identities [10].

Course Content: We collaborated with instructors at CU and ATC through in-person and virtual meetings to develop detailed outlines of four existing global health courses and identify relevant modifications to incorporate global health education competencies and immersive experiences. We aligned our student outcomes with the Consortium of Universities for Global Health (CUGH) framework of defined competencies for global health education [21] and the Accreditation Board for Engineering and Technology (ABET) providing national guidelines for the professional development of biomedical engineers [22],[23] (Table 1). We created lesson plans emphasizing cultural competency and a "design thinking mindset" [24],[25] through in-person and virtual interactions and engaging a community of practice of BME professionals. For example, cultural competency was reinforced through a weekly 10-15 minute student led presentation and discussion of predefined topics linked to the CUGH framework, focused on Tanzanian culture, healthcare, technology development, and education. The modified courses began enrolling students in Year 2 (fall 2025 and spring 2026) and we will report those outcomes in future publications.

Student Cohorts: After gaining institutional review board approval, we recruited student participants from four BME global health courses at CU and ATC. All students were categorized by the learning setting for practical immersion and design thinking (international, local) and type of global student exchange (in-person, virtual, none). **Cohort 1** included 22 (13 CU and 9 ATC) STEM students recruited in Year 1 (Jan-Aug 2025). **Cohort 2** currently includes 50 (42 CU and 8 ATC) STEM students and recruitment for Cohort 2 is ongoing in Year 2 (Aug 2025-May 2026). In Year 1, we also recruited a **Control Cohort** of 26 CU STEM students enrolled in a CU BME international research course that was structured as a traditional three-week in-person study abroad program. In May 2025, the Control Cohort of U.S. students traveled to Germany and France where all students participated in international practical and cultural immersion activities (24 events) within BME communities of practice but did not engage in BMED global health design activities or virtual interactions with ATC students.

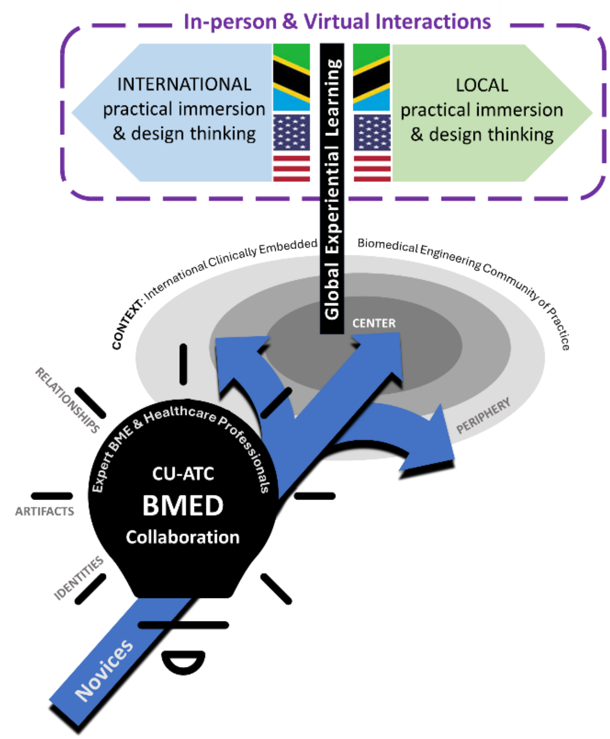

Figure 1: Aligned within a situated learning framework, BMED supports novices (students) in their journey from the periphery to the center of an international clinically embedded BME community of practice. BMED engages novices and experts (faculty, BME professionals, and healthcare/clinical professionals) in global experiential learning that involves a shared repertoire of practices (design thinking and practical immersion) using in-person and virtual interactions. Progress along the journey is assessed through the constructs of relationships, artifacts, and identities.

Data Collection Instruments: We used a mixed-methods approach to evaluate the BMED hybrid exchange model and data collection and analysis are ongoing. Quantitative data assessed students' global mindset using the Global Mindedness Scale [26] to measure perceived personal, professional, and cultural growth through 42 items on a 7-point Likert scale. Targeted survey questions assessed students' awareness of nine themes applied to low resource settings in health-related research [27] and engagement in BME communities of practice. Qualitative data consist of open-ended survey responses and participant interviews guided by SLT constructs addressing community setting, novice–expert relationships, activities, and identities. Survey and interview analysis is in progress, with six researchers independently coding transcripts in pairs and then comparing results to mitigate bias and develop a robust code dictionary. Initial codes were based on working definitions of major constructs within the SLT framework, with emergent codes refined through consensus. Codes developed from analysis of the Control Cohort provide a foundation for subsequent cohorts while allowing for new themes to emerge and helping establish qualitative analysis norms as the PI builds education research expertise as part of the grant activities. Except for the interviews, all data collection instruments were administered at pre- and post-engagement in the study abroad (for Control Cohort) or in-person/virtual activities in BMED (for Cohort 1).

Table 1: Student outcomes were aligned with CUGH competencies and ABET criteria.

BMED Student Outcomes	CUGH Competencies	ABET Criteria
SO1: We want our students to: • improve their cultural knowledge to enhance professional work involving team members from different racial and ethnic backgrounds • improve their abilities to identify and address healthcare needs in low resource settings in South Carolina and TZ	**3b** **5a** **7b**	**2** **4** **5** **b** **c**
SO2: We want our students to advance their skills for: • developing sustainable biomedical technology • pursuing successful careers working in global hubs of healthcare innovation and manufacturing	**5f** **7c** **11b**	

Results

We address first the results for our ancillary **mentoring goal** of developing engineering education research expertise. The lead author completed two formal courses on education research methods, designed the data collection instruments, and collected interview data in partnership with the second author. She then served as a "mentored mentor" leading engineering education graduate students in analysis of the interview data from the Control Cohort. Development of this research expertise led to the project results reported next.

Aligned with our **research goal**, BMED cultivated a design thinking mindset for innovating BME solutions to global health problems by enabling students to swap global locations and learn from each other, with virtual exchange experiences for a majority of involved faculty and students supported by in-person exchange for a subset. In Year 1, there was one period of practical immersion activities (April-August 2025) and two intervals of in-person global student exchange (ATC students to CU in April 2025, CU students to ATC in May 2025).

Cohort 1 included 8 of 22 students (36%) participating in international practical immersion and in-person global student exchange. The other 14 students (64%) participated in local practical immersion, with 10 students participating in virtual global student exchange and 4 students not participating in global student exchange. In other words, the BMED hybrid exchange model more than doubled the number of students (from 8 to 18) involved in global student exchange. It provided a novel way to address well-documented inadequate funding and other barriers that keep many students from participating in study-abroad opportunities [10],[28],[29],[30],[31],[32].

In Year 1, BMED faculty focused on embedding students into a community of practice of BME professionals. Our practical immersion activities centered on increasing cultural and global health knowledge and hands-on applications to reinforce students' development of a design thinking mindset, such as forming interdisciplinary teams that work with users, understanding the problem, sharing creative ideas, taking action, and testing prototypes. Students engaged with BME professionals in diverse settings, including healthcare facilities, medical and engineering research labs, and med-tech businesses. Students engaged in cultural activities in structured settings, as well as innumerable spontaneous events in which students sought their own cultural immersion. Specifically, Cohort 1 students engaged in BME communities of practice during 58 events hosted in South Carolina (47 events) and Tanzania (11 events) and cultural exchange activities hosted in South Carolina (22 events) and Tanzania (5 events).

While not all students participated in all events, a majority of students in Cohort 1 and the Control Cohort reported peer-to-peer sharing of professional knowledge and pursuing opportunities to develop their engineering skills in a practical setting. This trend was evident in both the pre- and post- intervals, consistent with highly engaged students. Analysis of students' interpretation of professional interactions and potential connections between the different types of global student exchange and activities will be explored further in Year 2. Additional details on the model and implementation will be forthcoming in future publications on this project.

The BMED hybrid exchange model provided a novel way to connect STEM students across continents and enrich their global mindset. Average measures of perceived personal and professional growth increased for students in Cohort 1 and the Control Cohort. Average measures of perceived cultural growth increased for Cohort 1 students from CU and ATC and remained constant for Control Cohort students. This may be explained by the lower proportion of Cohort 1 students who reported traveling outside their home country prior to their participation in the survey (63% for CU, 38% for ATC) compared to the Control Cohort (84%).

Conclusions

In summary, the BMED hybrid exchange model supports situated-learning in the context of an international clinically-embedded BME community of practice, which is effective for educating innovative, globally-minded engineering students and improving outcomes [3],[4],[5]. The hybrid model leverages limited resources in novel ways to enhance global mindset and engineering competencies for students enrolled in the program. This approach allows more engineering students to gain a global mindset and participate in clinically embedded biomedical engineering and experiential learning regardless of geographic location. It expands access to global exchange and cultural growth for engineering students who have limited access to in-person exchanges for various reasons (financial, or otherwise).

Broader impacts of this project include coursework development and transformation, STEM education training and outreach, professional enculturation, and teaching infrastructure. We involved over 20 CU and ATC faculty and 9 CU graduate students in development and delivery of course materials, defining relevant activities, and data collection and analysis, with an additional 40+ BME professionals involved in practical immersion activities with students at the international sites. Adopting a hybrid exchange model has potential broader implications, such as more students having unique experiences within BME communities of practice, notable student engagement in developing both biomedical engineering skills and global health competencies, and enhanced peer-to-peer interactions between students that essentially magnify the cultural knowledge gained from in-person exchanges.

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