2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering Education for 130 Years
ASEE
Paper ID #38563

Work in Progress: Engineering Health Equity: Perspective and Pedagogy of Interdisciplinary Teaching and Learning and Impact on Learners' Social Identity

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Engineering Health Equity: Perspective and Pedagogy of Interdisciplinary Teaching and Learning and Impact on Learners' Social Identity

Abstract

This research explored the beliefs related to the health disparities, systems, and innovation of honors/engineering students enrolled in a course on Health Equity. This course aims to bring together undergraduate students across disciplines from engineering, public health, pharmacy, anthropology, sociology, and other social and basic sciences to learn from each other through co-designing solutions to address health disparities. The Global Learning Short Scale Plus (G.L.S^{2+}) was used to assess students' beliefs related to global self awareness, cultural diversity, personal and social responsibility, understanding global systems, and applying knowledge to the contemporary global context. Qualitative and quantitative analyses showed **Personal and Social Responsibility** was a predominant factor influencing students' beliefs. Numerous experiences were identified as drivers of involvement or action with an interest in the global systems' factors.

Introduction

To ensure the successful and equitable implementation of health technology innovations, engineers must seek a holistic understanding of the intended contexts of use and both intended and unintended consequences of the technologies they design, implement, and supervise. However, curricula in fields such as engineering, technology, and computer science, traditionally focus concerted efforts on designing to fulfill technical requirements but neglect the needs of ecosystems and communities impacted by their technical solutions (Jordan et al., 2021). Equity is commonly addressed under a field-specific lens of privacy, clinical bias, gender bias, race/ethnicity bias, hardware and software availability, connectivity, and excluded identities (Abràmoff et al., 2022; Farrell et al., 2021; Fong and Harris, 2015). However, societal systems are interconnected across these fields and to increase health equity, it is necessary to address them as complex algorithms (McDonald, 2000).

In this document, 'health equity' is defined as a state in which everyone has a fair opportunity to reach their full health potential without disadvantages caused by their social, economic, or environmental circumstances. Course discussions emphasize that health equity requires equitable access to opportunities, power, and resources; the fair, just, and equitable distribution of public services and implementation of public policy; and the removal of obstacles (i.e., poverty,

discrimination) and inequities to build better outcomes for historically and currently disadvantaged populations (Office of Disease Prevention and Health Promotion, 2022; Braveman et al., 2017).

This study describes the development, implementation, and evaluation of a multidisciplinary and transdisciplinary course focused on engineering health equity. Using equity pedagogy, the instructors aim to create a learning environment and learning objectives that will support students to become reflective and critical citizens that can help build a just society (McGee Banks and Banks, 1995). Moreover, a transdisciplinary framework with student-centered strategies to address social and structural determinants that influence health structures, systems, and technologies at an undergraduate level offers a holistic opportunity to explore complex global problems (Velez et al., 2022).

Related Work

Health equity courses have been implemented at the graduate level at the University of Texas Austin (Lanier et al., 2022), senior undergraduates and early graduate students at Rutgers University (Riley, 2022), and health equity-focused machine learning algorithms introduced into introductory biomedical engineering courses at John's Hopkins University (Storm et al., 2022). Further, systems approaches to health equity are critical components of human factors and systems engineering (Roscoe et al., 2019). To date, however, the investigation into global self-awareness, perspective-taking, understanding, and application of global systems and context have not been investigated in these implementations.

Global mindsets and intercultural awareness are critical to understanding and designing for, diversity and equitable technology outcomes (Lee et al., 2012). While they are most associated with study abroad opportunities, global mindsets can be cultivated in engineering courses without traveling from campus settings by implementing cross-cultural dialogues, reflection activities, and individual mentoring Render et al. (2017). In that work, Render et al. (2017), demonstrated a significant increase in Intercultural Development Inventory (IDI) scores in a pre/post-test design over a one-year pilot program with undergraduate engineering students.

Theoretical Foundation

Equity pedagogies are achieved by fostering students' critical thinking, reflection, and gender/racial/cultural stratification (McGee Banks and Banks, 1995). They are implemented to assist diverse and/or minoritized student populations in their learning processes and outcomes (McGee Banks and Banks, 1995; Madkins et al., 2020). These pedagogies also facilitate creation, reinforcement,and behaviors that drive change (Madkins et al., 2020). The class assignments, content, and in-class activities were designed to encourage students' reflections and active attitudes toward social change. Equity pedagogy in the class was grounded on a student-centered course design. Students were actively involved in the acquisition and creation of knowledge (McGee Banks and Banks, 1995). In class, students examined design frameworks, design and re-design of health-related technology, discussions, and access to expert lecturers. Outside of class time, students work on creating glossaries, info-graphics, body of literature documents.

Methods

Research Questions

The following research questions guided this study:

RQ1 - What are the principal global factors cited by undergraduate students enrolled in the class?

RQ2 - What experiences elicited the global factors' relevance?

RQ3 - What goals do undergraduate students set based on factors' relevance?

Participants

The sample consisted of a total of eight undergraduate students, five from the Honors Program and three from the Biomedical Engineering (BME) major, enrolled in BME 39500 / HONR 39900 Engineering Health Equity. All participants self-selected and enrolled in the course. The sample was 75% female and 25% male.

Assessment

The Global Learning Short Scale Plus (G.L.S^{2+}) was adopted because it fills a current gap in the literature that aligns closely with the goal of this course, to develop a transdisciplinary framework that supports students in addressing social and structural determinants of health equity, while also guiding students through personal consciousness and interpersonal development (Holgate et al., 2020). These elements align with the AAC&U Global Learning VALUE rubric (American Association of Colleges and Universities, 2022), the basis for the G.L.S^{2+} (language in the prompts comes directly from the rubric). In particular, the integration of both understanding global systems and taking action to address these systems is missing from many more commonly used tools (e.g., the Intercultural Development Index). Additionally, the G.L.S^{2+} stands out for its mix of quantitative and structured qualitative reflection that provides insight at multiple points in the semester into student experiences and values, appropriate for both the topic and the small class size. While the tool is new, and initial adoption was slowed due to the pandemic, the G.L.S^{2+} has been used in a number of classes locally with a strong reputation for generating statistically reliable results that align pedagogically with efforts to measure student growth and development in accordance with the Global Learning VALUE rubric (Center for Instructional Excellence, 2023). We hope that our work will contribute to the validation of this tool as well as provide a model for others looking at developmental tools focused on student engagement with equity at multiple levels.

The Global Learning Short Scale Plus (G.L.S^{2+}) consists of 12 questions with a six-point Likert scale: 1 - *not at all* (I am not aware of or do not recognize this behavior), 2 - *low degree* (I am only aware of and recognize this behavior), 3 - *somewhat low degree* (I cooperate or comply with this behavior if required by others.), 4 - *somewhat high degree* (I recognize the value of and prefer this behavior), 5 - *high degree* (This behavior is an important priority to me), and 6 - *very high degree* (This behavior is natural to me, is habitual to me, and embodies who I am) (Center for Instructional Excellence, 2023). Additionally, the instrument has one open-ended section for

determining the relevant experiences and behaviors of the respondent. The instrument focuses on six factors:

- Global Self Awareness: Self-focus introspection can generate awareness of prevalent social systems and standards (Scaffidi Abbate et al., 2016).
- Perspective Taking: The ability to consider and reason based on another person's opinions, beliefs, and mental states (Pfeifer et al., 2009; Scaffidi Abbate et al., 2016).
- Cultural Diversity: Respondent intercultural competence and culturally driven analysis of societies and systems (Iseminger et al., 2020).
- Personal and Social Responsibility: An individual's premise to act considering how their actions affect other people, the environment, and society (Serrano and Zurn-Birkhimer, 2022).
- Understanding Global Systems: The ability to contextualize social norms that inform perspective, beliefs, economic standing, and policy, among others (Friedman, 2014).
- Applying Knowledge to Contemporary Global Context: implementation of global systemic perspectives (Friedman, 2014).

The G.L.S^{2+} has 12 positively keyed questions, thus resulting in a lower limit of six and an upper limit of 72. Table 1 presents the instrument questions and corresponding factors. Each factor is represented by two questions in the instrument. Table 1 provides the order in which the questions are delivered. Additionally, the G.L.S^{2+} also provides one open-ended question:

> Select items from numbers 1 to 12 (from the previous page) that you believe are most relevant to you. In the three spaces below, list the top three, with the first item to be most relevant to you in space one, the second item the next most relevant in space two, and the third most relevant item in space three. Write four concise sentences explaining the following:
>
> 1. Describe the experience
> 2. Interpret the experience: explain what the experience meant to you
> 3. Evaluate the experience: appraise the quality, value, or the importance of an expected experience
> 4. Provide a goal statement: what you will do during this trip, assignment, or experience to develop the specific behavior or experience you identified for the statement

Table 1: Global Learning Short Scale Plus $^{2+}$: Factors and questions.

Factor	Item	Question
Global Self Awareness	1	I reflect on how **MY** local actions toward the natural and human world can have a global impact.
	2	I reflect on how **OTHERS** specific local actions toward the human and natural world can have a global impact.
Perspective Taking	3	I consider **different cultural, personal, and social perspectives** to understand natural and human systems.
	4	I consider **different disciplinary, environmental, local and global perspectives** to understand natural and human systems.
Cultural Diversity	5	I examine the influence of power structures in society to understand inequalities among different groups.
	6	I ask questions without making judgments about people from other cultures
Personal and Social Responsibility	7	I discuss the importance of ethics and moral reasoning in a society.
	8	I examine different ways I can contribute to the local, national and global society.
Understanding Global Systems	9	I differentiate the effects of the natural (physical, biological, chemical, etc.) and human (economic, political, historical, etc.) systems on the access of resources for people.
	10	I identify the interrelationships among global systems to formulate solutions for change in society.
Applying Knowledge to Contemporary Global Context	11	I collaborate with others from different backgrounds to formulate practical solutions to challenges in society.
	12	I use my knowledge about historical and contemporary challenges in society to formulate practical solutions.

The G.L.S^{2+} assessment ties into the use of equity pedagogy by having learners reflect on the formation and perspectives brought by their own identity and beliefs systems, and evaluating the effects of societal and structural systems on social norms and responsibilities.

Learning Materials and Data collection

The course topics were chosen based on frameworks in public health, technology, and selected areas of health inequalities, highlighting the importance of intentional multidisciplinary and transdisciplinary approaches within the design, please refer to Figure 1. The class was designed to satisfy the requirements of BME students, social science ethics requirements, and honors students in the context of Competency-Based Education and Inquiry-Based Learning. The class also aimed to foster students' professional and academic skills, such as teamwork, problem-solving, critical thinking, multidisciplinary and transdisciplinary collaboration, ethical decision-making, and the ability to create materials to communicate difficult concepts. The three-credit course met 75 minutes twice weekly for 16 weeks. Data collection occurred in weeks one and 16 during class time (Figure 1). The data collection was not timed and was completed during class hours.

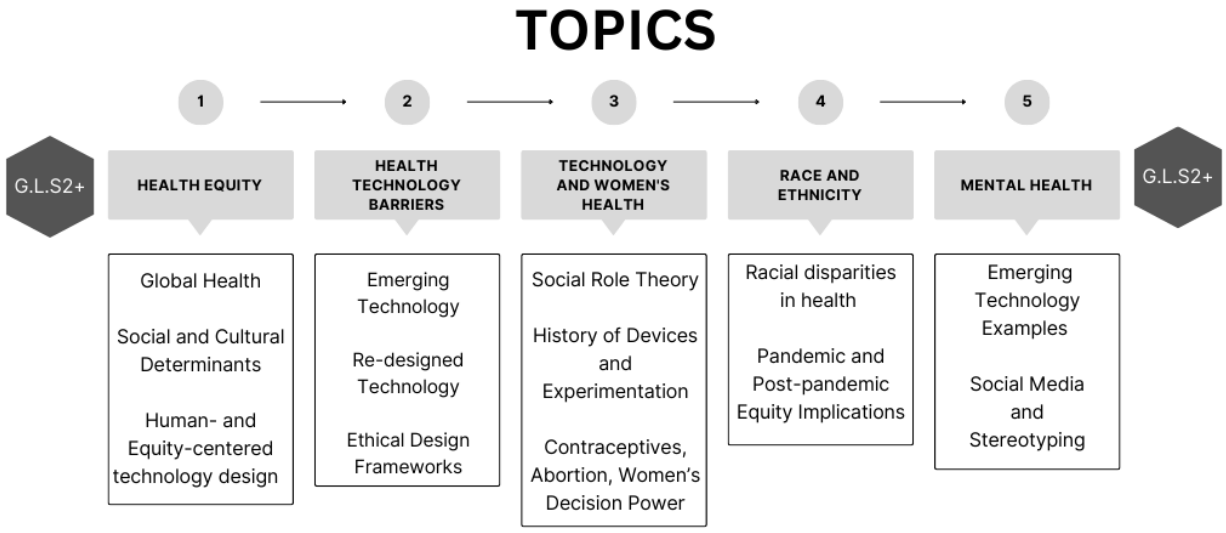


Figure 1: Data collection and topic introduction overview

Data analysis

Responses to the (G.L.S^{2+}) were subjected to descriptive (mean, mode, standard deviation) and inferential (t-test) statistical analysis for examining RQ1. Inductive techniques of qualitative analysis were used to enable the understanding of experiences and the impact of these experiences (Buse et al., 2013). Codes were defined using in vivo for answering the RQ2 and process coding for responding RQ3 (Cho and Lee, 2014; Saldaña, 2016). In vivo coding uses words or phrases provided by the participants in their statements (Saldaña, 2016). Process coding has used the actions triggered by the experience described, Saldaña (2016) states that this type of codding is suitable for observable actions in the data. Codes in this study are mutually exclusive. Multiple codes are possible in a single response.

Results

Table 2 presents the pre-test descriptive statistics for each factor assessed. Each factor groups two questions (please refer to Table 1). The factors with the highest mean were Cultural Diversity and Personal and Social Responsibility. The factor with the lower overall mean was Understanding Global Systems.

Table 2: Global Learning Short Scale Plus $^{2+}$: Factors' descriptive statistics for pre-test.

Factor	*N*	*M*	*SD*	Minimum	Maximum
Global Self Awareness (Items 1 and 2)	8	6.87	1.64	4	8
Perspective Taking (Items 3 and 4)	8	8.37	1.59	6	11
Cultural Diversity (Items 5 and 6)	8	8.50	1.77	6	11
Personal and Social Responsibility (Items 7 and 8)	8	8.50	1.30	7	11
Understanding Global Systems (Items 9 and 10)	8	6.50	2.07	4	11
Applying Knowledge to Contemporary Global Context (Items 11 and 12)	8	7.75	1.66	4	9

N = number in sample, *M* = sample mean, *SD* = standard deviation

Descriptive statistics for the post-test are presented in Table 3. The factor with the highest overall mean was Cultural Diversity followed by Perspective Taking.

Table 3: Global Learning Short Scale Plus $^{2+}$: Factors' descriptive statistics for post-test.

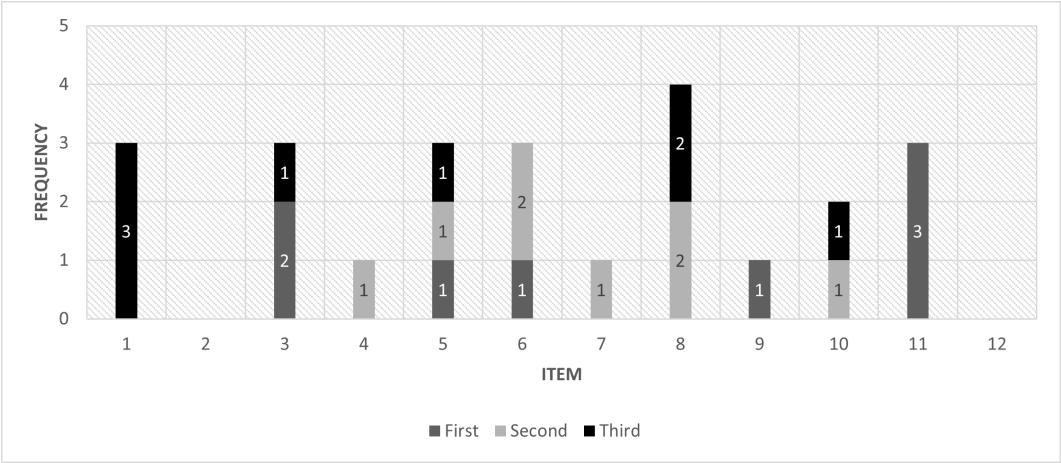
Factor	*N*	*M*	*SD*	Minimum	Maximum
Global Self Awareness (Items 1 and 2)	8	9.50	1.07	8	11
Perspective Taking (Items 3 and 4)	8	10.13	1.95	6	12
Cultural Diversity (Items 5 and 6)	8	10.25	1.16	9	12
Personal and Social Responsibility (Items 7 and 8)	8	9.88	1.25	8	12
Understanding Global Systems (Items 9 and 10)	8	9.00	1.77	6	12
Applying Knowledge to Contemporary Global Context (Items 11 and 12)	8	9.63	1.59	6	11

N = number in sample, *M* = sample mean, *SD* = standard deviation

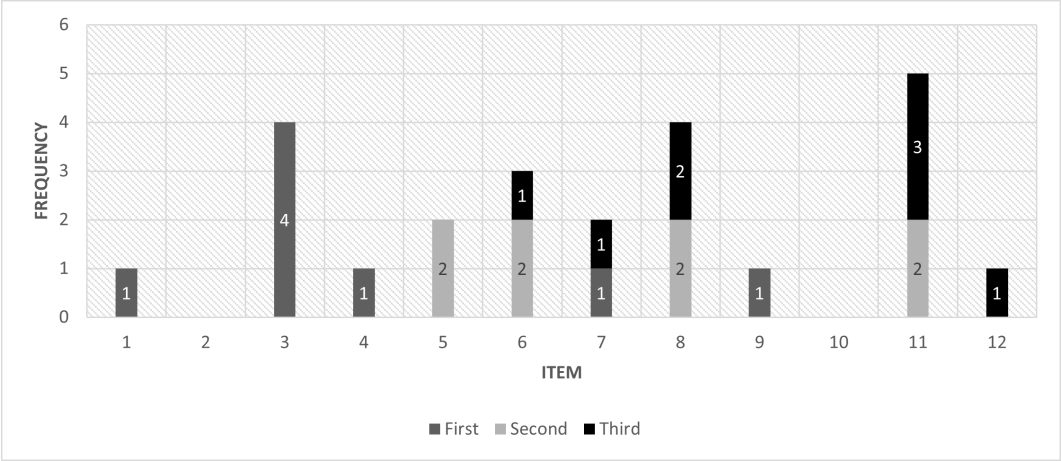
Although the mean increased for all the factors, the paired t-test, using $\alpha = 0.05$, showed that there was a significant difference between pre-test and post-test scores for **Global Self Awareness** [$t(7)$=-5.27, p=.0012], **Cultural Diversity** [$t(7)$=-2.41, p=.0467], and **Understanding Global Systems** [$t(7)$=-4.41, p=.0031].

The pre-test showed that the most cited item was 11 (*I collaborate with others from different backgrounds to formulate practical solutions to challenges in society*) in the first spot of relevance. Thus, applying knowledge in a contemporary context is flagged as a driver for students in this class. In the second relevant event students cited 6 (*I ask questions without making judgments about people from other cultures*) and 8 (*I examine different ways I can contribute to the local, national and global society*) the most. Finally, in the third in relevance, the event most cited was 1 (*I reflect on how MY local actions toward the natural and human world can have a global impact*). Overall the most cited item, regardless of relevance, was 8. However, the overall factor driving their behaviors was **Personal and Social Responsibility**. Figure 2(a) shows the frequency distribution for each item for the pre-test. The post-test data showed that the most cited item was 4 (*I consider different cultural, personal, and social perspectives to understand natural and human systems*). In the second relevant event, there was a tied between items 5,6, 8, and 11. Finally, in the last relevant event, item 11 was the most frequently cited. The overall most cited item was 11 and the most recurring factors were **Personal and Social Responsibility** and

Applying Knowledge to Contemporary Global Context. Refer to Figure 2(b) for details.



(a)



(b)

Figure 2: Bar graph for item frequency by relevance for each item (a) pre-test and (b) post-test.

Activities that triggered the relevance of an item were class activities, course content, desire to improve their professional skills, immigration, curiosity, global challenges, feelings of inadequacy, real word engineering activity, international academic experience, moving to a new city, religious engagement, job hunt, socialization, and volunteering opportunities. Finally, goals set by students include volunteering, learning about global systems that contribute to a lack of equity, trying to understand others' perspectives, applying knowledge, considering the cultural background, contributing towards improving equity, and being sincere when discussing equity issues with others. On the post-test, 75% of the students focused on class activities experienced in the Engineering Health Equity course, such as listening to guest speakers, group / individual activities, and reflections.

Discussion

The qualitative analysis showed that class content, volunteering opportunities, and the application of skills to address real-world problems are experiences that foster global learning factors. These results align with Bielefeldt and Canney (2016) findings which stated that volunteering opportunities and courses were a driving factor for maintaining social responsibility beliefs in engineering students. The class content elicited awareness of all factors in most students.

Additionally, activities cited as triggers are social. Scaffidi Abbate et al. (2016) stated that social interactions are crucial to be able to consider other people's opinions. Incorporating others' perspectives is crucial for understanding, discussing, and changing systems that foster inequality. Class materials were often used to showcase the perspectives of multiple populations.

Furthermore, experiences such as international hands-on academic experiences, immigration, and relocation were related to the relevance of **Cultural Diversity**. Oda et al. (2018) stated that immersive international educational programs were correlated with an increase in **Cultural Diversity** beliefs of engineering students. The course materials accommodated multiple hands-on activities on the design/redesign of healthcare-related technology.

Conclusions and Limitations

Conclusions

- The principal global learning factors cited in the pre-test by students enrolled in BME 39500 / HONR 39900 Engineering Health Equity were **Cultural Diversity** and **Personal and Social Responsibility** based on the multiple choice answers. The qualitative analysis confirmed the quantitative results pointing to **Personal and Social Responsibility** as a predominant factor influencing students' beliefs. The post-test showed that based on the multiple choice questions, students increased and prioritized their awareness **Perspective taking** and **Cultural Diversity**. The open-ended questions showed that students valued **Personal and Social Responsibility** and **Applying Knowledge to Contemporary Global Context**.
- Activities that triggered the relevance of an item were class activities, course content, desire to improve their professional skills, immigration to the United States, curiosity, global challenges (*e.g.* global warming), feelings of inadequacy, real word engineering activity, international academic experience, moving to a new city, religious engagement, job hunt, socialization, and volunteering opportunities.
- Goals set by students include volunteering, learning about global systems that contribute to a lack of equity, trying to understand others' perspectives, applying knowledge, considering the cultural background, contributing towards improving equity, and being sincere when discussing equity issues with others.

Limitations

The sampled population self-selected to enroll in BME 39500 / HONR 39900 Engineering Health Equity. The class content might be attractive to a particular set of students that may have personal beliefs related to equity. Further limitations of this Work in Progress include the G.L.S^{2+} reliability and validity having not yet been established and the small sample size in this pilot implementation of the course. Future implementation of the course and the potential use of additional assessments will be needed to validate these initial findings.

Future Work

The authors plan to deliver a second iteration of the class with updated curricula based on students' recommendations and instructors' experiences.

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