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Work in Progress: Exploring the Impact of a Pre-Capstone Health Equity Design Sprint on Students' Conceptions of Health Equity

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Background: Amidst a troubling increase in health disparities in the U.S. and globally [1], health technologies are under heightened scrutiny for their impact on health outcomes. Numerous examples exist [2,3,4,5] of medical technologies with “harmful oversights” in the engineering design process, often resulting in disproportionately harmful health outcomes for vulnerable and marginalized populations [6]. Despite a growing consensus that medical device design processes must consider health equity [7], challenges remain for faculty working to transform their BME curriculum. BME programs often link primary design learning outcomes to capstone courses, creating an opportunity to integrate health equity concepts into the curriculum. However, capstone courses encounter specific curricular challenges. While stakeholder engagement is crucial in engineering design, it is difficult to facilitate community-based involvement due to off-campus stakeholders and conflicting schedules [8,9]. There is limited research on effective stakeholder engagement in BME design education and its impact on engineering skills [10]. Thus, enhancing stakeholder involvement in capstone courses and addressing health equity offers a chance for curricular innovation. We aim to address these challenges by piloting a health equity-focused design sprint, Designing Accessible Solutions for Health (DASH), prior to a BME capstone design course. In this work-in-progress paper, we examine the impact of the pilot program through one of our program’s research questions: *how do students’ perceptions of health equity change over the course of the health equity design sprint?*

Methods: This research exploration is part of a larger initiative at [blinded] that aims to improve health equity in rural Appalachia by catalyzing development of health technologies through expanded community engagement with rural healthcare providers in Appalachia. As part of this larger initiative, we launched a 5-day design sprint before the 2024 Fall semester, aiming to boost the capstone projects' impact through team building, immersion in the Stanford Biodesign process, and enhanced customer discovery. Students (n = 4) tackled a problem statement from a local client with foot drop in the Appalachian region. The design sprint was facilitated by two Biodesign Fellows (graduate students with Bachelor’s degrees in BME) and two BME faculty members, guiding students through workshops on social determinants of health (SDOH), user needs, stakeholder engagement, patient co-design, and refining problem statements.

Participants and Data Collection: For Fall 2024, one capstone team of four rising senior students was selected for the DASH pilot experience. In this work-in-progress paper, we focus on qualitative data collected via pre- and post-program concept maps exploring students’ conceptions of health equity. Students were individually tasked with creating concept maps about health equity on the first and last day of the program. No materials about SDOH/Health Equity were provided before the program. We leverage concept maps as a widely accepted assessment tool for evaluating students’ mental models of a given domain [11, 12, 13]. This work was reviewed by the [blinded] Human Research Protection Program (IRB #24-823) and determined to not meet the definition of research involving human subjects.

Data Analysis: Concept maps were coded for key themes [14] and scored on comprehension of concepts, in alignment with recommendations in [15]. Utilizing recognized categories to improve health equity in BME as a guiding framework [16], coding definitions (Table 1) were expanded to align with program goals.

Table 1: Defined Codes with Examples

Code	Definition	Example term from concept map
Barriers/SDOH	Social determinants of health and external factors related to a user's health experience	"Proximity to health care"
Accessible Health Solutions	Design considerations toward equitable solutions	"Considers physical barriers"
Community- Based Design	Participatory methods that engage engineers directly with users	"Stakeholder engagement"

Results:

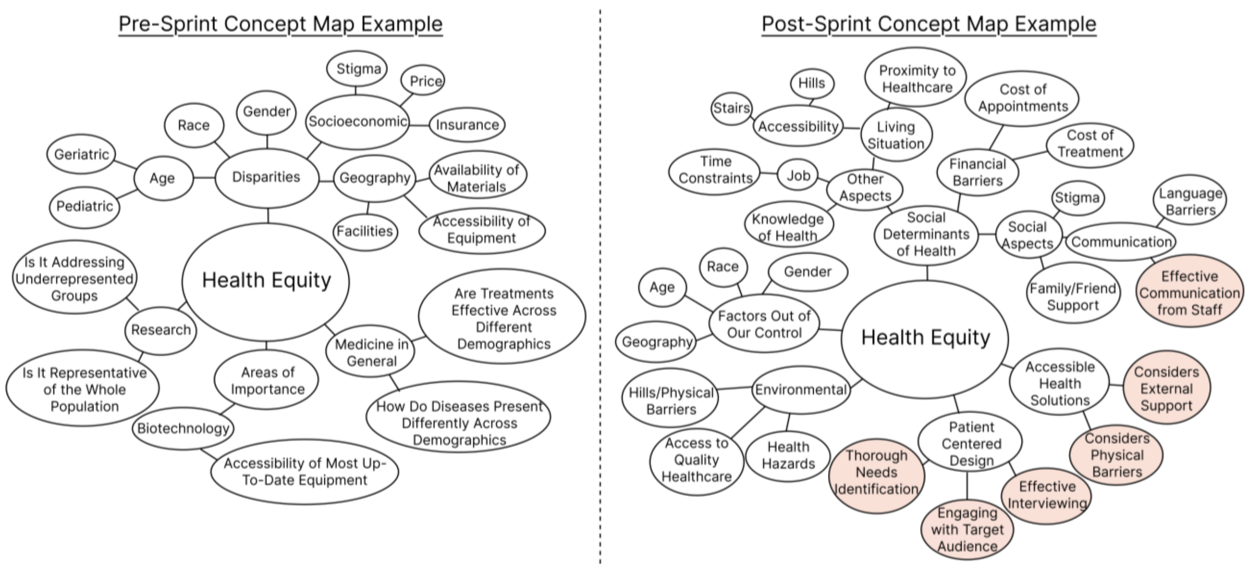

Figure 1: Pre- and Post-Sprint Concept Map Participant A Example

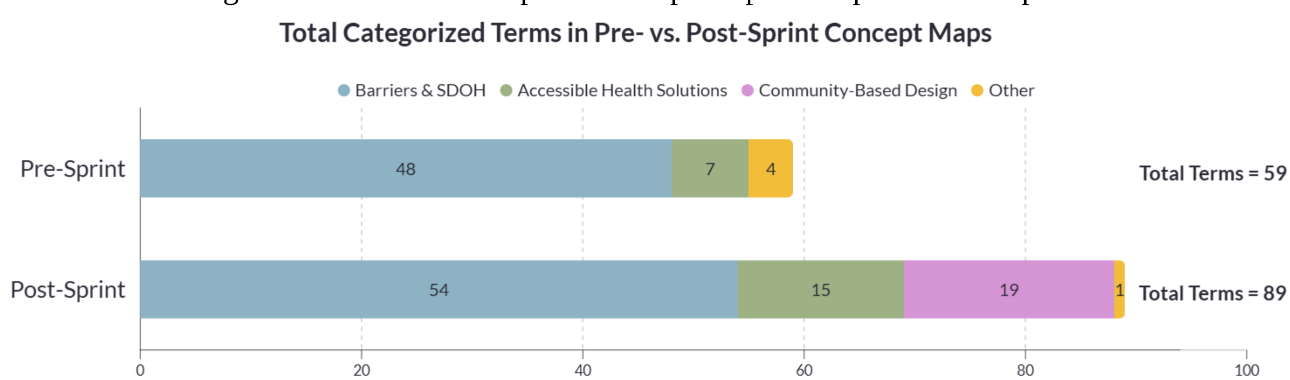

Figure 2: Categorized Terms

Our preliminary data analysis revealed two key insights. First, the mental models of health equity grew in complexity from the start of the sprint to the end. Initially, there were 59 total terms (terms defined as a single "bubble") whichincreased by 150% to 89 terms post-sprint, with new terms like "Social Determinants of Health" and "factors out of [BME] control" emerging from the lectures and activities. Additionally, the students adopted more active language in their post-sprint maps, using phrases such as "Engaging with target audience" and "Effective communication from staff," indicating growing awareness of their participatory role.

Second, the post-sprint maps demonstrated a deeper integration of health equity and design thinking through semantic memory theory [13]. Post-sprint maps highlight *new* additions to students' mental models of health equity, many of which were directly connected to the design process. Prior to the sprint, students exhibited minimal integration of these concepts (Fig. 1), whereas post-sprint maps showed deeper understanding of the intersection between the topics, highlighting terms like "Patient-centered design" and "Thorough needs identification." Notably, the Community-Based Design category increased from 0 to 19 terms, indicating successful retention of the interconnections highlighted during the sprint.

Discussion: A key success of the sprint was the deep engagement between the students and their local client. Throughout the program, we emphasized the interrelationship between health equity and design thinking through activities and lectures about codesign, community engagement, and strategic interviewing skills. Students had the opportunity to immediately implement these skills through multiple meetings with the client and clinicians over 3 days. On the final day, they collaboratively ranked user needs identified during the sprint with the client, allowing member checking while involving the client in the design process (Appendix). This activity substituted for a final presentation to emphasize the significance of co-design. The increase in terms related to the intersection of design thinking and health equity in the students' concept maps reflects the classroom emphasis and the intensive hands-on work completed in a short timeframe. Another success of the sprint was the strong team dynamics built on trust and vulnerability among the students and their client. We facilitated relationship-building activities, such as team icebreakers, group lunches, car rides, immersive brainstorming sessions, and informal chats with the client over snacks and drinks. As the sprint evolved, we observed the students and client becoming increasingly comfortable sharing ideas and suggestions with each other.

For future program iterations, we aim to expand our collection of program assessment data in two key ways. First, we would expand the post-program longitudinal data collection , enabling analysis of the impact of the design sprint on student success during senior capstone. We plan to expand our data collection to include CATME team assessments throughout the academic semester, which will provide insights on team dynamics and individual experiences. Finally, quantitative data collection will be expanded by incorporating existing validated scales to better understand the impact of the design sprint on students' engineering design competencies. While we piloted these measures this year, our data was significantly limited in sample size. We plan to incorporate adaptations of Grohs et al. Systems' Thinking Assessment Tool [17] and Carberry et. al's [18] instrument for assessing students' engineering design self-efficacy. Combined, these additional measures of program assessment data will enable an expanded understanding of the most impactful program elements. Ultimately, our goal is to develop scalable, effective models for learning experiences, including pre- or within-semester models, that improve students' stakeholder engagement and robust understanding of health equity.

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Appendix:

Who We Are

We are a team of Biomedical Engineers focused on Designing Accessible Solutions for Health (DASH). Our capstone project is to design an improved orthotic for foot drop.

Our Goals

- Investigate gaps in existing ankle-foot orthotics (AFOs) for patients in rural areas
- Design an AFO that addresses the unmet needs of patients
- Actively engage with the client at every stage of the design process to promote human-centered design
- Gain a deeper understanding of the Biomedical Engineering design process

Problem Statement

A way to **support patients** with drop foot due to nerve injuries in order to enhance mobility and increase access to a wide **variety of environments**.

Timeline

August & September
Discovery (interviews, regulations, patents, standards)

→

October & November
Concept Generation & Initial Prototyping

→

December
Proof of Concept Testing & Results

The Team

User Needs	
Need	Importance
Ankle Support	
Full Foot Support	
Durability	
Functional with and without shoes	
Accessibility of repairs and replacement parts	
Minimize risk of secondary injuries	
Aesthetics	
Fit	
Ease of use	
Access to uneven terrain	

1	Extremely unimportant
2	Somewhat unimportant
3	Neither important nor unimportant
4	Somewhat Important
5	Extremely Important