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Looking Ahead: Socio-Technical Understanding and Local Impacts: Developing a Community Health Assessment in Civil and Environmental Engineering Senior Capstone

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INTRODUCTION

With the majority of STEM workers in the U.S. identifying as White or Asian (82% combined), Black, Hispanic and Indigenous STEM professionals are underrepresented in the STEM workforce (18%, combined), most specifically within remunerative STEM fields including engineering (14%) (Funk and Parker 2018). Black, Hispanic and Indigenous underrepresentation in STEM results from race-based biases across a spectrum from structural to personal that include: the continued framing of STEM as fields in which the production and dissemination of knowledge are "*neutral and unconnected to power relations*" (McGee 2020; Rohde et al. 2020); faculty unwillingness or inability to teach engagement with the social impacts of engineering decision-making (Niles et al. 2020; Jimenez et al. 2021); and, within engineering, a focus on social issues often occurring only via international service learning (Boucher et al. 2020; Bielefeldt et al. 2021) in which the ethics of 'doing good' are centered around humanitarianism and engagement elsewhere in the world. An implication of Black, Hispanic and Indigenous under-representation in STEM is that STEM professions, and specifically, engineering, risk continuing to be practiced in a manner that does not explicitly acknowledge how the decision-making frameworks embedded within STEM can serve to perpetuate biases that, in turn, result in disparities in access to health, opportunity and resources at the community level within the U.S.

Key words: Knowledge gain; Capstone projects; Design thinking

METHODS

Consistent with emerging ABET frameworks to address inequality within STEM education, as well as to grapple with the social inequities that STEM training can perpetuate, we have developed a teaching module and capstone deliverable within the Senior year two-semester capstone sequence in the Department of Civil and Environmental Engineering at the University of Maine (Orono, ME). Overall, and with specific focus on the challenges noted above, the module is intended to directly introduce engineering students to the linked social and technical histories of built environments and the impacts of socio-cultural biases on the shaping of these environments. By introducing this content in Engineering Project Management (CIE 413) during the first semester of capstone, our goal is to deepen student exploration into questions of how and where infrastructure has historically been placed (or not) in U.S. cities. Our approach has evolved iteratively as follows:

In 2021, Merritt created a one-week course module (Mapping the City) for CIE 413 that focuses on the 20th century infrastructural history of a city familiar to our students (Portland, ME), highlighting neighborhood-scale, social and economic legacy impacts of Urban Renewal-era decisions in the city. Following module presentation and discussion, capstone teams were assigned a U.S. city in which to explore both city-scale and neighborhood-scale engineering and infrastructure histories. Students researched how placement of rail lines and highways impacts community access; how the U.S. history of redlining can perpetuate disparity in housing quality; how land use history can impact neighborhood susceptibility to flooding and reliability of water and sanitation infrastructure; and potential for chemical exposures in drinking water, soil or air. Explorations focused on: Boston, MA (North End); New Orleans, LA (Tremé); Los Angeles, CA (Sugar Hill); Portland, OR (Albina) and Pittsburgh, PA (The Hill). In a subsequent oral report-out and with guidance from Merritt and Nagy, students discussed patterns in infrastructural decision-making, including noting substantive overlap amongst cities in the demographics of neighborhoods that continue to suffer health and socio-economic impacts as the result of where infrastructure was historically placed.

Based on student feedback, we moved this past year toward asking students to foreground the evaluation of local health impacts within each of their teams' capstone designs. To this end, we followed the case study module for Portland, ME with a more narrowly focused exploration of a Portland neighborhood (Bayside). In the city's current vision to redress an Urban Renewal-era highway placement, there are concerns that proposed neighborhood improvements remain overly focused on automobile transit. Following overview of the issue, including specific focus on a community garden that could be bisected by a proposed transportation re-design, and open class brainstorm on how pedestrian access could be improved in the vicinity of the garden, we introduced a Health and Local Environment Impact Assessment (HLEIA).

The HLEIA is a six-question framework designed to identify and evaluate community demographics and land use; potential health-positive and health-negative impacts of scoped projects; contextual details on the location in which a proposed work is scoped; and potential impacts and possible outcomes with respect to water and air quality, soil stability, local food security, community mobility, and exposure to hazards in the environment. The HLEIA arises from a Social Determinants of Health framework in Public Health (CDC 2024) and is intended to encourage technically proficient STEM students to consider socio-cultural dynamics and demographics within and adjacent to project area boundaries. In application, we walked the class through a model HLEIA for the Bayside transportation re-design, then provided teams with the HLEIA template as an assigned component of final capstone deliverables.

PRELIMINARY RESULTS

For the initial iterations of the module in which students researched infrastructural histories for selected cities, we received generally positive informal feedback from capstone classes of 50 students, including direct mention from approximately 20% students that the information we'd shared (for Portland, ME) and guided them towards (for their assigned cities) was wholly new within their engineering curriculum. For both years in which we asked students to present on U.S. cities, there were multiple students (perhaps 10% of the class) who experienced and expressed 'lightbulb' moments regarding how cities are structured, including noting informally how absent socio-technical framing has been in other coursework. We believe that this exercise resulted in notable direct engagement within several capstone teams per year (so, approximately 10-15 students per year) and that the opportunity to facilitate exploration and discussion amongst students of impacts of engineering decisions on health within the U.S. is of significant value in the engineering curriculum. Importantly, even for those students who didn't directly articulate enthusiasm for the content, this teaching module facilitated engagement with evaluating social impacts of engineering decision-making. With respect to the new HLEIA component of capstone introduced this past year, overall student deliverables in the 2nd semester of capstone were encouraging, with many teams identifying specific, potential community health concerns in the vicinity of their project locations that would likely have otherwise gone under-examined. There were no consequences (positive or negative) regarding the quality of the HLEIA submitted by each capstone team; rather, the HLEIA was included as a team deliverable as an opportunity for students to practice engaging their technical tasks with a wider socio-technical lens.

NEXT STEPS

In working to incorporate the HLEIA into the capstone experience, Nagy has noted that in creating a 2nd semester deliverable for the exercise, students were completing the HLEIA in parallel with their engineering design without applying outcomes to inform final design-related decisions. We are continuing to advance the HLEIA for the upcoming academic year and are evaluating whether the deliverable can be accomplished during Fall semester (1^{st} semester) to better facilitate integration of the results into final capstone designs. We will be able to evaluate the extent of integration of HLEIA outcomes relative to this past year (HLEIA deliverable as a component of 2^{nd} semester of capstone), as well as previous years (no explicit focus on community health or social impacts of engineering design in capstone). With this exercise, we hope to foster engagement amongst engineering students and faculty on how best to incorporate more direct curricular focus on spatialization of health disparities, as well as on persistence of biases in the practice of STEM professions.

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CIE ENGINEERING CAPSTONE: HEALTH AND LOCAL ENVIRONMENTAL IMPACT ASSESSMENT

1. Summarize general demographics for the location in which the work is being scoped; include characterization information on racial and ethnic composition, age demographics, wealth distribution, and one additional factor (of your teams' choice) to help understand who lives in the location in which your project is being scoped or undertaken.
2. Identify three (3) communities who may be impacted by the work being scoped; as example, 'communities' can be characterized by: size factor (##), scale factor (geography), or focus factor (special interest or activity; age-restricted demographic) as is relevant for your project.
3. For each of the three (3) communities your team has identified, describe at least one potentially health-positive benefit of the project being scoped and at least one potentially health-negative impact of the project being scoped.
4. Provide three (3) spatially-contextual details on the location in which the project is being scoped; think about this as describing (as example): the site within the neighborhood; the neighborhood within the general area of town; and the general area of town within the city. For rural projects, consider the site within the town and the town within the county as well as the broader geography (e.g., rural coastal; rural inland; rural mountain).
5. In the vicinity of the site during implementation, identify preliminary potential impacts to:
   a. Waterways and water quality
   b. Air quality
   c. Soil stability
   d. Food-growing potential and local food security
   e. Community access and mobility
   f. Community exposure to hazards in the environment

6. Following implementation, identify potential outcomes of the project with respect to:
    a. Waterways and water quality
    b. Air quality
    c. Soil stability
    d. Food-growing potential and local food security
    e. Community access and mobility
    f. Community exposure to hazards in the environment