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Evolving the Curriculum: Evaluation of the Integration of Social Justice and Social Determinants of Health into the Undergraduate Engineering Curriculum

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Abstract

Evolving the Curriculum: Evaluation of the Integration of Social Justice and Social Determinants of Health into the Undergraduate Engineering Curriculum

This practicum evaluated the potential for integrating concepts of social justice and public health into the standard U.S. ABET-Accredited undergraduate engineering curriculum. This project was undertaken with the guidance of the Dean of the College of Engineering at the University of Maine (Orono, ME) with the goal of assessing whether and how thematic content focused on the impact of engineering decision-making on social determinants of health could be woven through engineering coursework. The practicum was conducted via identification of colleges and universities in North America that include aspects of community focus in either/both undergraduate and graduate engineering curricula; evaluation of the relevance of those programs to this practicum objective; and recommendations for evolving the existing University of Maine engineering program. Overall, for the 19 colleges and universities in North America that specifically award some level of certification, minor, major or graduate degree in health and/or justice aspects of engineering, the majority of these awards specifically center international development and/or global humanitarianism (including disaster relief) as majors or minors. In the context of this practicum, a shortcoming of these programs is that they do not foreground the role that engineering has played – and continues to play – in creating and exacerbating inequities in health and access between different communities as a function of race and/or class within this country. Explicitly addressing this shortcoming within the undergraduate engineering curriculum is a crucial component of evolving the engineering curriculum toward a toolkit for addressing social injustice in the U.S.

Aims and Rationale

The fields of civil and environmental engineering are primarily responsible for planning, designing, and constructing facilities to serve and provide for the health and safety of society. Within the field of civil engineering, these facilities include highways, railroads, bridges, tunnels, airports, harbors, hydroelectric dams and power plants and the foundations and frames of buildings. Within environmental engineering – including water resource engineering – responsibility and focus include planning, design and management of water treatment plants, pollution control facilities including wastewater treatment, as well as other infrastructure, technologies and approaches (e.g. numerical modeling) with a focus on water resource management, environmental protection (including flood control and natural disaster management) and environmental remediation.

Undergraduate training in civil and environmental engineering includes the technical content of the engineering degree program as well as coursework that contextualizes engineering within a framework of Human Values and Social Context (HVSC). Courses that satisfy requirements for competency in HVSC specifically include courses on ethics in engineering as well as courses focused on writing and public presentation skills. With respect to ethics in engineering, the coursework focuses on ethical principles and behaviors for guiding one's career as a professional engineer, and as such, principally centers engineers themselves.

What appears to be under-developed in this approach to teaching values, context and ethics within engineering is a framework for centering the relational aspect of this topic, namely, the role that cultural history – and the intersection of that history with industry and engineering – has played in defining and perpetuating societal perceptions of Human Value. That is, where engineering is applied – where infrastructure is built (or not) and how it is maintained (or not) – profoundly influences the quality of environments in which communities live. If there are differences in the application and quality of that infrastructure that orient along cultural fault lines of race and socio-economic status (which there are and do), then the question of what constitutes ethical and values-oriented behavior in engineering should extend beyond the behaviors of individuals to include the orientation of the profession itself.

Specifically, Social Context for ethical behavior in engineering should center an understanding of the role that engineering, infrastructure and the built environment have played in creating, exacerbating and perpetuating inequalities in access to clean water, clean air, supportive transportation, flood control and drainage management, functioning sanitation, physical safety and the structural soundness and health-safety of materials used in construction in this country. Being poor and/or Black or Brown should not mean needing to accept a home, a neighborhood or a community environment that is actively damaging to health as a parenthetical aside to the broader American cultural narrative of technological improvement as proof and/or manifestation of progress in society.

What is wanting then within the engineering curriculum is a more explicit linking of engineering as technology (t*he how*) with public and community health as an orienting principle (*the why*). Although

sanitary engineering – the integration of *the how* and *the why* with respect to water and waste removal/treatment service provision – does exist (at least historically) as a discrete field within the engineering profession, its instruction and practice have been subsumed – and often with a loss of the focus on public health as a discipline with its own approach and pedagogy – within the broader contemporary field categorization of environmental engineering. Importantly, to the extent that there is a legacy-oriented focus on community health within the environmental engineering curriculum, this focus does not sufficiently center the role that engineering has played in creating and perpetuating health disparities within U.S. society. That is, a focus on overall 'public health' without explicit recognition of the role that engineering plays in creating community-level disparities in health access is an absolution of the profession, by the profession, for the social context in which engineering decisions get made.

With this context as guidance, this practicum followed three specific lines of inquiry:

- To what extent do North American colleges and universities currently offer minor, major or graduate degrees in community health and/or social justice aspects of engineering?
- What basis is there for the argument that public health and social justice should be better integrated into ABET-accredited engineering programs?
- Is it possible to demonstrate through sample course content and curricula frameworks that the integration of public health and social justice with engineering fits within the existing course framework at a state University (University of Maine) engineering program?

Development of the topic and lines of inquire has not changed significantly over the progress of the practicum. It has been my experience professionally as a consulting engineer and as a University engineering instructor (part-time) that the engineering mindset has not traditionally been flexible in how it addresses the social aspects of technical problem-solving. It is this inflexibility and the associated discomfort with thinking about disparities in whom engineering decisions affects that led me to pursue this MPH and to focus on curriculum reframing for this practicum.

My conclusion after review of existing North American engineering programs is that although there are newly emerging fields within engineering instruction (including Humanitarian and Development

Engineering) that do center individual and community health as the basis for programmatic foci on water and/or sanitation service provision as well as structural and transportation-oriented needs, the orientation of these programs is predominantly international. Acknowledging fundamentally that the technical training in disaster relief and/or the provision of access and sanitary services in locations in which infrastructure does not currently exist have profound and critically important Human Value, this disciplinary focus on global engineering begs a critical question, namely: how do we center civil and environmental engineering instruction in the United States not just on *the how*, but also on *the wh*y and *for whom* here within this country? This question is not one of how to '*do good out there*' as individual engineers under emergency conditions and/or with limited field resources, but rather how to orient the profession itself toward addressing the challenges, biases and inequalities in how services are provided (or not) and health consequences are distributed within already-built environments in the U.S.; environments that the field of engineering continues to play a role in planning, designing, constructing, adapting and ultimately remediating or removing entirely.

My intention is to continue with this work with the goal of integrating these programmatic ideas into the undergraduate engineering program over time. Specifically, I have been talking with the Department of Civil and Environmental Engineering (CIE) at University of Maine regarding how to incorporate public health and social justice more directly into the curriculum. As presented in this practicum, there are options for incorporation across categories; options we are discussing (D) or for which we are currently developing content (C) for this next academic year include:

- Creating lecture content for lower-level CIE courses that present Social Determinants of Health as a framework for thinking about impacts of engineering design and how those impacts vary significantly as a function of race and class (C);
- Creating modules to offer to faculty to teach in upper-level electives within the CIE focus areas of transportation, structural, water resource and environmental engineering (D);
- Providing options for engineering students to complete their HVSC electives in courses that include aspects of community health and/or social justice (D);
- Providing options for students to undertake design projects focused on equity and access (C);

- Creating courses for required CIE science and technical electives that focus on community engaged science and socio-technical understanding in engineering (C); and
- Creating a credential program so that students are able to graduate with a transcript stamp indicating coursework, portfolio work, and social context work in social justice (D).

Approach, Methods and Findings

The initial review and programmatic evaluations for this practicum has entailed four steps:

- Step One: Review existing curricula for colleges and Universities in North America that highlight course or programmatic offerings in Public Health, Social Justice and/or Humanitarian Engineering;
- Step Two: Select a relevant programmatic structure at each level of offering (i.e., undergraduate concentration, minor or major; and/or graduate degree) to evaluate how the content is organized;
- Step Three: Review the University of Maine undergraduate CIE curriculum to identify courses in the curriculum where community health and social justice content could be brought into focus; and
- Step Four: Identify existing courses from other departments that can fulfill CIE HVSC requirements; options for creating community health and social justice content within existing CIE courses; and potential for creating new courses that fulfill CIE elective requirements for which community health and social justice course options are not currently available.

Results of this review and evaluation have been tabulated in Excel (see attached) to include the programmatic offering, the academic level of offering (e.g., undergraduate concentration; undergraduate minor; undergraduate major; and/or graduate certification or degree), the specific requirements in terms of hours, credits and/or suggested programmatic sequencing and confirmation of ABET-accreditation.[1] Accreditation matters in that my intention is to develop strategies for increasing focus on public health and social justice within existing accredited engineering programs.

In addition to this review and evaluation, I have also been: developing the funding justification for what I believe is the need for evolving the engineering curriculum; and creating case study content as a demonstration of how to expand the presentation of technical content in engineering courses to create a

[1] Accreditation Board for Engineering and Technology - https://www.abet.org/accreditation/

socio-technical framework within engineering. I intent to find funding for an expanded position at University of Maine (and/or elsewhere) to develop the curriculum options I've presented above.

The principal reason for the necessity of this curriculum evolution is that to see inequity requires seeing the forces – socio-cultural, administrative, and legal – that create, sustain and perpetuate unequal access to resources. To see inequity requires seeing infrastructural history: waterways, bridges, canals, highways, pipelines, harbors, depots, rail yards, and asking questions: What got made where? When and how? On the scale of the intersection, what lies buried and what gets built? What grows? On the scale of the neighborhood, who gets walled in or blocked out? What got razed to the ground and rebuilt as something else in the name of (someone else's) progress? On the scale of the city, what gets done now with what got left when (and where) what was made back then got closed up, filled in, shipped out or moved along? Who lives there and who doesn't?

If it is one's job to maintain infrastructure, it is important to see the long patterns and the biases inherent in its placement and maintenance. Seeing these patterns and biases is critical because Human Values and Social Context fundamentally ground our engineering profession in people and communities. If you don't see the long patterns and the biases then you as an engineer – in service to your profession in engineering – will repeat the mistakes that have created, perpetuated and exacerbated social inequality and health inequity. Importantly, neither economic efficiency nor environmental sustainability as guiding criteria for the field of engineering will implicitly foreground social justice in decision-making; challenges to equity in the health of communities are only able to be addressed if they are seen; they will only be seen if they are looked at directly. Think of this as tracing the shape of something that you've allowed yourself to be encouraged not to see.

Regarding Case Study content, there are four (4) practice areas in CIE that can/should inter-link directly with community health and social justice content. These practice areas are transportation, structural, water resources and environmental engineering. In theory, case study content can be threaded in two directions: (1) by practice area; and (2) by geographic location. Focusing on practice area, themes and topics that should be addressed are as follows:

- Transportation engineering - Where do highways get placed and how does the impact of infrastructure placement impact community health in terms of mobility and access to health-positive choices in food and community activities?
- Structural engineering – How does the U.S. history of redlining, restrictive covenants and administrative forms of residential segregation create disparities in the availability and quality of housing in ways that directly limit health choices for impacted communities?
- Water resource engineering – How does this same legal and administrative history create disparities in neighborhood susceptibility to flooding? How does it create disparities in access to functioning water/sanitation services? How does it create disparities in infrastructural resilience and resultant impacts on individual and community health in the face of sea level rise and climate change?
- Environmental engineering – How does where one lives create different health scenarios in terms of chemical and/or physical (particulate) exposures in air and water? Are there fundamental and measurable differences in air and water quality that map to residential location by zip code, census tract or other measure of spatial disaggregation?

For a Case Study approach organized by geography, a city (or cities) can be selected and explored over the course of a semester to evaluate the socio-cultural, technical, legal, administrative and economic factors that have created conditions in that city that impact individual and community health. Resources that can be brought to bear on these questions include:

- Mapping Inequality: https://dsl.richmond.edu/panorama/redlining/#loc=5/39.1/-94.58;
- Social Vulnerability Mapping: https://dsl.richmond.edu/socialvulnerability/
- US EPA Environmental Justice Screening and Mapping Tool: https://www.epa.gov/ejscreen
- Racial Demographic Dot Map: http://racialdotmap.demographics.coopercenter.org
- Undesign the Redline: http://www.designingthewe.com/undesign-the-redline
- US EPA Environmental Justice and Systemic Racism Speaker Series: https://www.epa.gov/environmentaljustice/environmental-justice-systemic-racism-speaker-series
- America ReFramed (e.g., Pruitt-Igoe Myth: https://vimeo.com/ondemand/thepruittigoemyth)
- Research literature for discussion and reflection (see suggested reading | reference list)

As a demonstration Case Study, socio-technical mapping could be undertaken to help move students from a narrow prescriptive focus on 'problem-solving' to a broader more nuanced understanding of

'problem-framing'. The distinction here is in encouraging engineering students to think about what the role of the engineer has been (and is) in *creating* the conditions in which public health and social justice problems manifest and what the role (if any) of the engineer can be in *resolving* the problem For a case study focused on Flint, MI and the drinking water crisis that surfaced in 2014, facets of socio-technical mapping would include a focus on individuals, neighborhoods and the city as a whole and include:

- The role that U.S. social history has played in quality, function and placement of infrastructure – the social and technical evolution of the city over the 20th century through the arc of industrialization, segregation, redlining, White flight and suburbanization; job loss; urban renewal; city shrinkage, and regionalization and what the impact of these forces mean for inequities in how health is understood, experienced and spatially distributed;
- The regulatory frameworks for managing water quality – specifically, examining the Lead and Copper Rule (LCR) – how regulatory limits are defined and implemented and the extent to which they function – by design or by behavioral bias – to preserve the infrastructural status quo versus functioning to reduce disparities in exposures and health impacts;
- The context and strategies for social engagement as a function of power hierarchies within politico-technical systems, including: (a) engagement WITHIN frameworks (e.g., citizen science); (b) resilience OUTSIDE of frameworks (e.g., mutual aid, urban farming, food brigades); and (c) pushback AGAINST frameworks (e.g., organization, protesting, rebellion);
- The concept of *cognitive boundaries* - how we define pollution; how we define 'we' (i.e., the public, community); how we define 'acceptable risk'; how we (re)consider 'normal' and the need for a level of 'acuteness' in problems before response is mobilized. Why is it so hard to focus on chronic problems? Concept of *accommodative orientation* and why the cultivation and maintenance of networks of amicability so often takes precedence over the protection of public health; and
- The role of language in codification, absolution/abdication and framing in discussion of professional responsibility and actions within hierarchy; the need to challenge the reflexive use of passive tense and associated deflection as tools for maintaining the cultural status quo (e.g., consider the difference in implicit and explicit meaning between: structured racism versus structural racism).

For this practicum, the literature that I've reviewed, the organizational structure I'm creating and the demonstration of curricular need that I'm compiling remain close to the goals I'd formulated in undertaking this MPH and organizing this practicum.

Assessment of Practicum Site's Roles and Responsibilities for Public Health

University of Maine is a land grant public University with the mission of reasonable-cost education across science, engineering, nursing, teaching and liberal arts. Programs and services at the University to improve the health of the community are myriad and include instruction for students, community outreach via Cooperative Extension, research, consultation with public, private and political entities, and symposia, panels, talks, and performances accessible to the public. Within the University, the College of Engineering, and, specifically, the Department of Civil and Environmental Engineering with whom I'm working, perform many of these same services in a topic-focused manner.

On the specific topic of Public Health, the Educational Objectives of the Civil Engineering Program state that graduates will work professionally as engineers to '*promote and advance public health and safety, and enhance quality of life*.' I believe that this statement shapes a goal for engineering graduates to 'do good for the public' as builders and maintainers of water, sanitation, flood control, housing, and roadway infrastructures as well as remediators of air, water and soil for protection of human health and the environment. The use of terms such as 'public health' and 'quality of life' in the Educational Objectives without coursework for learning to see inequality, however, perpetuates blind spots and biases in who the public is perceived to be. My recommendation for addressing these blind spots and biases in the engineering curriculum is as I've presented here in this practicum assignment. To thread concepts and examples of social justice throughout the curriculum will graduate engineering students with the ability to foreground the often easily invisible disparities in health that result from how decisions regarding infrastructure shape access to health. What students of engineering and infrastructure need to grapple with is that access to health – beyond those personal choices made affordable and available as a function of one's race and socio-economic status – is an issue of social justice regarding which the profession of engineering is not a neutral observer.

Competencies Attained

- Competency: Public Health & Health Care Systems – This competency is fundamental to the reason that I've undertaken this MPH. As I've described throughout this report and included in the attached list of organized reading materials, we live in a society in which race × class act as gatekeepers and obstacles to the ability to access Health. Professional fields such as engineering (although not limited to engineering) are complicit in this gatekeeping through decisions that have been (and continue to be) made about where infrastructure is placed (or not) and how it is maintained (or not). Infrastructural issues with relevance here include placement of highways and railyards; structural quality/integrity of housing; maintenance of water and sanitation infrastructure; and remediation prioritization around environmental hazards. I intend to focus the MPH capstone on this subject.
- Competency: Communication – I am currently talking with the Chair of CIE regarding strategies for integrating these social justice and community health topics into engineering coursework. Current plans for the 2021-2022 academic year include: (a) social equity-focused capstone projects; (b) guest lectures in an undergraduate course focused on engineering decision-making; (c) starting the process of turning the proposed Socio-Technical Mapping elective into a seminar course; (d) working with CIE to envision a 5-year plan for an increased equity focus; and (e) continuing to write, teach and encourage the broadening of engineering capacity for equity-oriented social engagement.
- Competency: Systems Thinking - As noted above, the profession in which I work has (and continues to) played a significant role in creating barriers to access. These barriers influence who studies engineering as well as how communities are seen (or not) in decisions regarding where infrastructure gets built. As described earlier to this report, although public health, and specifically, the provision of water and waste removal/treatment for public health – is a focus within the engineering profession, the concept is often very broadly conceived. To the extent that there is a focus on community health within the engineering curriculum, this focus does not sufficiently center principals of equity and the role that engineering has played in creating and perpetuating health disparities within the U.S. The incorporation of social justice explicitly into engineering coursework is a systems thinking approach to tackling the structural challenge of disparities in access to health and safety that are core challenges of ongoing racial bias in the U.S.
- Competency: Public Health Practice (C1) – This practicum evaluates the extent to which public health concepts (e.g., Social Determinants of Health) are currently incorporated into the civil

engineering curriculum at the University of Maine and provides recommendations and strategies for increase pedagogical focus on social justice and community health in the curriculum. Importantly, the curriculum review undertaken here, while conducted for the University of Maine, can be conceived as an approach for other universities to conduct curricula review. As is evident from the deliverable for this practicum, there is much that CIE can do with currently available HVSC electives and modular content for existing CIE courses that can begin to amplify social justice themes without requiring re-arrangement of the curriculum OR impacting ABET-accreditation. With respect to Public Health Practice Competency, this practicum looks directly at the infrastructural origins of public health disparities and provides a framework for examining the role that culturally-centered decision-makers (i.e., technically trained engineers) play in limiting (previously) and potentially creating opportunities for increased access to Health.

- Competency: Public Health Practice (C5) – The necessity of assessing power structures – including the roles, responsibilities and often conflicting mandates of governmental and/or non-governmental organizations in providing programs and services to improve community health – is a critical component of evolving the engineering curriculum. As example, regarding governmental organizations, the socio-technical Case Study approach I've described above focused on Flint, MI, will require an exploration of the Federal USEPA regulatory framework for monitoring urban water quality (e.g., the Lead and Copper Rule [LCR]) as well as the role of the Michigan Department of Environmental Quality (DEQ) and the city of Flint municipal government in (poorly) overseeing and enforcing compliance with respect to the LCR. The Case Study approach also includes focus on modes/strategies of community organizing and community response as one of the multiple frames of references for evaluating engineering works. That is, the goal with a focus on community-level organizing and response is to encourage engineering students to foreground the social context in which engineering decisions are made and to directly reflect on perspectives that challenge the bias professional engineers can carry regarding their reliability and trustworthiness as 'rule-makers'. Likewise, the role of the media as alternately upholders of the status quo versus platforms for the dissemination of alternative narratives, including the perspective of whistle-blowers and truth tellers, is a vital component of exploring access and power.

Reflecting on the competencies listed here, my belief is unchanged that these competencies are critically important aspects of working to integrate social justice and public health more directly into

engineering education (and practice). I selected these competencies based on their value in evolving my own (as well as my students') thinking on what a 'socio-technical' lens for engineering education and practice would look like. That is, to provide engineering students with the ability to see their work within social contexts requires a contextual rooting in U.S. racial history, power dynamics, race × class-based barriers to access, and resultant disparities in individual and community capacity for health. This practicum has provided the framework for articulating the linkages between these central tenets of public health and where/how they can fit into the structure of an ABET-accredited engineering program. This practicum plus the capstone thesis (Fall Semester 2021) are, in my mind, both the culminating requirements for the MPH and the next steps in the slow curve of professional re-direction that has been my focus since starting to work toward the MPH.

Reflection on the Practicum

Based in large part on COVID-19, I've had very little direct interaction with faculty in CIE over this past academic year. This to say, I've been mostly working and teaching independently. The feedback that I have received from other faculty with whom I've discussed this curriculum project has been positive and engaged. I have been working in recent weeks on the process of identifying capstone design options that include social equity requirements, as well as creating course content to be introduced as modules in two 2021 Fall semester courses. Once the process of in-person academic re-engagement is further along this fall, there will also be opportunities for more direct faculty engagement with these programmatic ideas via seminars, departmental presentations, and the course development process. Societally, over the past 18 months, I think we have experienced an expansion in the U.S. in the recognition of how consistent and unrelenting the push must be for advancement toward social justice; an expansion that is perhaps reaching demographics in society who have previously allowed themselves to overlook and ignore the persistence of racial bias in 21st century America. There is nothing fortuitous about timing of either COVID-19 or this practicum exercise for addressing societal racial bias; rather, the experience of this practicum has been the next needed step for me in clarifying my thinking regarding the need for new organizing principals in the fields of civil and environmental engineering.

Conclusion

In evaluating the current undergraduate engineering curriculum nationally, I believe that the framework currently used for teaching domestic (state-side) engineering in the U.S. retains a large legacy component of the Cold War: mostly single criterion decision-making optimized for scale (large) and efficiency, with an implicit recognition that a future generation of engineers and scientists (in addition to, more fundamentally, future generations of impacted communities) will have to grapple with the damage later. There is a fixedness of purpose in this approach that historically encouraged the advancement of those most able to linearize their thinking, a demographic that was socially constrained in ways that have created and perpetuated marginalization and disparities in access to health and safety for much of U.S. society. This approach of optimization and linearization for assessing infrastructural and societal needs doesn't describe the society we live in (and never did). It is my belief that we need a structure for engineering education now that isn't built on a foundation of last century's global geopolitical binary, and that re-orienting the field toward supporting the Social and Physical Determinants of Health – *those conditions in the environments in which we are born, live, learn, work, play, worship, and age that determine our capacity for health in all forms* – is a fundamentally sound foundation to build upon. Access to health – beyond those personal choices made affordable and available as a function of one's race and/or socio-economic status – is an issue of social justice. It is my belief that engineering as a profession should be in service to creating, improving and ultimately sustaining that justice.

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Case Study: Socio-Technical Mapping – Flint, MI

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