Forced Displacement and Engineering Education: Developing the Curriculum for a Course on a Global Crisis

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Abstract

More than 110 million people have fled their homes due to war, persecution, and the effects of climate change and other disasters. This number is expected to increase significantly given several ongoing conflicts around the world. Although forced displacement is one of the great global challenges of our time, insufficient attention is paid to this issue within higher education, and it is rarely explored in courses on engineering and basic and applied sciences. While some models do exist for integrating concepts associated with forced displacement into STEM education, they rarely provide students the opportunity to approach the issue holistically and engage in depth. Such courses tend to focus only on select issues, use siloed approaches, and consider complex challenges in isolation from other inherently related challenges.

Simply mapping the concept of forced displacement onto existing course models is insufficient, as engaging with the issue of forced displacement at any level requires holistic, interdisciplinary thinking. On March 9-10, 2023, the Center on Forced Displacement (CFD) at Boston University and the Committee on Human Rights (CHR) of the U.S. National Academy of Sciences, National Academy of Engineering, and National Academy of Medicine hosted a workshop premised on this idea. The workshop brought together experts in the fields of engineering, human rights, forced displacement, and pedagogy to develop a course aimed at preparing STEM students to help address challenges associated with forced displacement, several of whom are currently working to pilot versions of these courses at their respective institutions across the country. A follow-up workshop scheduled for May 2024 will examine lessons learned during these pilot courses and explore opportunities for scaling up this project. In this paper, we explore gaps in existing STEM curricula that demonstrate the need for such a course, describe outcomes of the workshop, outline essential elements of a course effectively introducing STEM students to this topic (including historical and political context, moral and ethical frameworks, lived experience, human rights principles, and technical and analytical skills, as well as suggested teaching strategies), and present our own approaches, through the course we are currently piloting at Boston University called *Engineering Approaches for Refugee Health,* in aiming to create a course that not only instills in students a long-term desire to engage with the issue of forced displacement but also empowers students to tackle similarly complex issues requiring interdisciplinary thinking.

Background and Motivation

Globally, more than 110 million people have been displaced due to conflict, persecution, and the effects of climate change and other disasters, and these numbers are only expected to increase [1]. Although forced displacement is one of the great global challenges of our time, insufficient attention is paid to this issue within higher education, and it is rarely explored in courses on engineering and basic and applied sciences. Forcibly displaced communities often live in conditions affected by conflict, in informal settlements or other areas with poor housing

conditions affected by environmental hazards, and they tend to be at an increased risk for various health challenges due to structural barriers to healthcare, employment, and formal housing as well as poor and overcrowded housing conditions. [2, 3] Paired with social factors such as exclusion and marginalization, these conditions lead to unique risks to the health and well-being of forcibly displaced communities. These challenges do not begin once a destination is reached; in many situations, the conditions that lead to displacement and the difficult journeys that follow also contribute to creating and exacerbating health risks among forcibly displaced communities. The challenges faced by these communities are complex and require an understanding of the process and drivers of forced displacement. Humanitarian agencies working in at-risk communities, are often in need of not just cash and medical supplies, but also require trained professionals who are comfortable with technology, can guide innovation, and can provide guidance and training to others in the appropriate use of technology [4]. Both emerging and long-term humanitarian crises have created an endless demand for engineers who are willing and capable of channeling their skills towards working to alleviate the suffering of those displaced from their homes [5]. While the demand only continues to grow, the supply of such individuals remains limited, in part due to the limited training opportunities to engage with these issues. Despite the opportunity and need for engineers to engage with and attempt to help alleviate many of these challenges, including by contributing to the landscape of technological solutions aiming to improve the health and well-being of forcibly displaced communities, little has been done to incorporate these topics into engineering curricula.

While some models do exist for integrating concepts associated with forced displacement into engineering education, primarily through courses on humanitarian engineering initiatives, these courses rarely provide students the opportunity to approach the issue holistically and

engage with the various aspects of forced displacement in depth [6, 7, 8, 9, 10]. For example, while design-based courses might take students through the engineering design process and allow them to apply their technical skills to develop interventions to be used in a refugee camp or low-resource setting, they do not always provide students with the background necessary to design interventions that are culturally appropriate and rights-respecting. Such courses often focus only on a select few issues, like those related to water, sanitation, and hygiene using siloed approaches, considering the challenges they seek to address in isolation from other inherently related challenges. In addition, limited attention is paid to the causes of forced displacement, or the impact of protracted displacement on quality of life and well-being. Detailed analyses of current technological solutions and their limitations or potential harmful impacts in contexts of forced displacement remain poorly discussed and understood. Existing frameworks also tend to consider only narrow definitions of displacement, which might exclude internally displaced people (IDPs) and stateless communities, as well as people living in conditions beyond typical refugee camps (e.g. in urban informal settlements). Some of these frameworks also fail to treat forced displacement as a process, rather than a single event, resulting in a failure to examine the various challenges that exist throughout the entire journey. Therefore, we see a need for dedicated efforts meant to incorporate the concept of forced displacement into STEM education as more than just an afterthought, recognizing that any examination of the topic requires equipping students with an understanding of the relevant historical, legal, and sociological contexts associated with the issue, as well as an ability to think critically and approach issues from interdisciplinary perspectives.

Simply mapping the concept of forced displacement onto existing models is insufficient, as engaging with the issue of forced displacement at any level requires holistic, interdisciplinary

thinking. For example, for students to think responsibly about the types of interventions that may be useful in a refugee camp, they must first understand the social, ethical, and political factors that often turn temporary arrangements into protracted situations, spanning generations. To appropriately address the health challenges of stateless individuals, students need to understand the factors that have led to statelessness and the resulting denial of basic rights, as well as the far-reaching and long-term effects on the lifestyles, health, and well-being of community members. Students cannot effectively work to introduce digital technologies in an informal settlement housing individuals who've fled persecution without first understanding that particular attention must be paid to preserving the rights and privacy of those fleeing hostile governments, and their expected hesitance to accept unfamiliar technologies as a result. Students also need to learn how to use a range of frameworks (e.g., human rights, ethics) when examining complex issues such as forced displacement. Integrating forced displacement into engineering education offers an opportunity to expose students to the potential of using their technical skills to address complex societal challenges. It can also demonstrate the limitations of approaching such issues from a single perspective and the shortcomings of working within isolated disciplines. Though the aim of such a course is to instill in students a long-term desire to engage with the issue of forced displacement, framing concepts this way can also empower students to tackle similarly complex issues requiring interdisciplinary thinking beyond their time in the classroom.

Course Planning and Development

Recognizing the need for courses/modules meant to equip engineering students, through interdisciplinary approaches, with the skills needed to help address challenges associated with forced displacement, we (the Center on Forced Displacement (CFD) at Boston University), in

partnership with the Committee on Human Rights (CHR) of the U.S. National Academy of Sciences, National Academy of Engineering, and National Academy of Medicine), hosted a workshop to explore the creation of such a course. Held on March 9-10, 2023, the workshop gathered experts in the fields of engineering, demography, human rights, innovation, migration, forced displacement, and pedagogy [11]. Given the inherently interdisciplinary nature of issues surrounding forced displacement, we felt it necessary to engage scholars and practitioners reflecting a broad range of expertise and disciplinary backgrounds in the process of developing and planning this course. Bringing together a diverse group of experts also allowed us to maximize the reach and impact of this course by helping us develop a broad, flexible course model that can be refined and adjusted to fit specific regional, university, and departmental contexts.

Facilitating all of these discussions through the workshop, which brought together academics and practitioners of a range of expertise, also allowed for an exchange of materials and resources and built a community of support that those who offered the course could lean on in the process of developing it. The group worked together to compile a list of guest lecturers, which could prove useful given that most STEM faculty may not feel qualified to speak on every topic the course covers and would allow for a diversified presentation of materials, and offered to record guest lecturers to be shared for others to make use of in their own classes.

Since we envisioned the course being adapted for different formats, levels of complexity, and engineering disciplines, we sought to develop a general course sketch outlining the overall objectives and aims, suggested content, potential teaching strategies, and assessment methods, which could be adjusted as needed to meet the needs of instructors. Following the workshop, we also pooled a range of teaching materials (assignment ideas, readings, videos, etc.) into a

repository accessible by instructors to help them more easily incorporate these themes into their teaching. This approach, which could be replicated by others seeking to introduce new topics into established curriculum, appears to have been successful, as three workshop participants are currently piloting variations of this course (including versions for both undergraduate and graduate students), and several others have committed to or expressed interest in doing so in the near future. Given that not all departments will have faculty who have experience working on issues related to forced displacement or in contexts affected by it, creating this community and compiling a set of resources, which group members could contribute their respective expertise to, is especially important in broadening the impact of this course. In the future, we hope to create an open-access repository consisting of lecture series (both long and short videos, Q&A with those with lived experiences etc), worked out examples, sample assignments and exercises that can be adapted for particular courses. Below we have outlined some aspects the course sketch developed through our workshop, which may be useful to instructors seeking to introduce similarly complex topics into STEM courses.

Bearing in mind that courses may have different technical focuses, we developed broad learning objectives and outcomes that would be relevant across disciplines and could easily be made more specific as needed:

<u>Course Aims</u>

- Introduce students to the issue of forced displacement and relevant historical, political, and social contexts
- Help students understand the potential role of STEM in contributing to forced displacement-related challenges as well as in mitigating and addressing these challenges
- Prepare students to critically engage with moral and ethical issues associated with forced displacement, including through a human rights lens
- Equip students with analytical and technical tools needed to help address challenges associated with forced displacement

Learning Objectives

- Explore the topic of forced displacement-related challenges from different disciplinary perspectives and represent the associated historical context in all its complexities (political, cultural, sociological, etc.)
- Understand the moral and ethical dilemmas of forced displacement interventions from both human rights and design perspectives
- Understand how STEM fields can contribute to forced displacement solutions as well as challenges
- Understand tenets of ethical leadership and how to apply them
- Understand systems thinking and design processes and apply them to forced displacement-related interventions
- Develop skills in data representation, visualization, interpretation and analysis, and be able to apply them in situations related to forced displacement
- Be able to critically analyze the impact of new and existing technologies on those experiencing forced displacement

Recognizing that the specific course content will vary from department to department and based on the prior experience and training of the targeted student group (e.g. sophomore, junior, senior, graduate), we still felt it would be useful to develop an outline of content that would be necessary to teach in any course addressing forced displacement (such as related to the processes, conditions, causes, and challenges associated with forced displacement). For example, to ensure students have a common understanding of what the instructor means by "forced displacement", the workshop group felt that all courses should begin with an overview of the topic, including definitions of key terms and categories (such as "refugee", "forced displacement", "internally displaced person", "asylum", and other relevant terms) and a conceptual overview of changing patterns of forced displacement over time. Workshop participants also felt there were certain universal concepts related to forced displacement that were essential for ensuring students tackle associated issues effectively. These include presenting displacement as a journey/process rather than as a single incident, highlighting the unique challenges which arise at different points in the forced displacement process, explaining why people move by presenting the various drivers of forced displacement, and providing an

overview of the limitations and impacts of relevant legal frameworks (for example, why one person might be granted asylum while another is not). Workshop participants felt that courses should make clear the role engineering can play in addressing or exacerbating forced displacement-related challenges. One approach to address this is by highlighting examples of "failed" interventions in the field of humanitarian engineering, which has been cited as a powerful teaching tool [12]. Instructors may want to provide examples of both motivating opportunities to engage as engineers and examples of engineering interventions that failed not because of design flaws but due to limitations in the mainstream development discourse, which often fails to consider the importance of local contexts and knowledge or ethical implications of technological interventions, in order to convey to students that there is much to be done and improved upon [12].

Workshop participants also felt it was important that students be educated on and engage critically with moral and ethical frameworks, as well as the international human rights framework, as they pertain to designing interventions for forcibly displaced communities. Responsible intervention design requires students to understand the ethical complexities that arise when engaging with these issues, such as what it means for an intervention to be sustainable, who is truly benefitting from the proposed intervention, and why the 'Do No Harm' principle does not go far enough in this context [13]. It is also a useful practice for instructors to dismantle common misconceptions students may bring into the course, including those rooted in techno-solutionism, the idea that even the most complex human challenges have simple technological fixes. Instructors may present the limitations of technological interventions by presenting examples such as the iris scan system introduced in two large refugee camps in Jordan, which would allow them to pay for their groceries by scanning their eye [14]. While

those who introduced the technology tout its efficiency and reduction of paperwork, the natural hesitance of those residing in the camps to accept an unfamiliar technology, especially one that collects mass biometric data or can only make life saving provisions available to one member of the household, was overlooked, especially given that many refugees have fled oppressive governments and might be fearful of how such identifying information could be used against them. (This example, and many others like it, also reinforce the need for the kind of training this course provides, which equips students to think proactively about the potential consequences and ethical implication of a technology, rather than controlling the damage it creates after it is too late and has impacted lives, an important skill for any engineer, regardless of the particular path their career takes.) This technology also raised significant human rights concerns related to consent and privacy [15]. These, and similar, examples can help students develop their critical thinking skills and consider issues like what it means to design ethical interventions, whether a technological solution is even necessary in all cases, the particular importance of preserving the privacy and security of forcibly displaced people, and the value of designing interventions with the concerns, safety and priorities of the affected communities in mind.

Cultural competency was flagged by workshop participants as a key teaching point for this course outline. Effective interventions require an understanding of the local norms and culture, and that a solution that is effective in one place may not be in another. In addition, instructors should help students recognize that local perspectives are just as important, if not more, as the technical understandings they contribute, and instructors should allow students to challenge and deconstruct models for intervention rooted in colonialism, such as the White Savior model [16].

One of the principles participants identified as most critical to a course of this nature was a focus on lived experience. The incorporation of first-person accounts (such as through interviews, personal narrative, short films, or literary excerpts) of lived experience help to humanize the issue. Instructors may also choose to incorporate a number of regional case studies throughout the course, or focus on a particular regional context throughout, and explore individual stories and experiences in detail. Facilitating all of these discussions through the workshop, which brought together academics and practitioners of a range of expertise, allowed for an exchange of materials and resources and built a community of support that those who offered the course could lean on in the process of developing it. The group worked together to compile a list of guest lecturers, which could prove useful given that most STEM faculty may not feel qualified to speak on every topic the course covers and would allow for a diversified presentation of materials, and offered to record guest lecturers to be shared for others to make use of in their own classes.

Specific technical concepts covered in the course will vary depending on the course level and department. The pilot course offered at Boston University in Spring 2024, *Engineering Approaches to Refugee Health,* which will be described in more detail in the sections that follow, was offered to upperclassmen. The majority of the enrolled students were juniors or seniors in Biomedical Engineering, with a few students from computer engineering and mechanical engineering. The course included the following technical skills and concepts: data representation, analysis, and visualization (including evaluating data quality, critical understanding of how data are created and resulting impacts on narratives), systems thinking and design (through network analysis), mathematical modeling techniques for health applications and their limitations (such as SEIR methods and Markov chains), design frameworks and the importance of human-centered

design (through analysis and critique of existing interventions), evidence-based measures of performance (e.g. How is success measured? What does it mean for an intervention to be sustainable?) and communicating with a broad audience through presentations and writing assignments such as op-eds.

Faculty Engagement and Institutional Support

Gaining support for the course we propose and allowing it to become a sustainable part of engineering curricula requires thinking about how to motivate faculty to engage with the topic of forced displacement in their teaching. Along with challenges associated with the fact that engineering curricula are often quite inflexible, with very little room to introduce electives or new courses, workshop participants commented on the tendency (within academic spheres) to believe that when engineering courses deviate from their traditionally siloed approaches and attempt to integrate social issues within their curriculum, they inevitably lose their technical rigor. Faculty interested in integrating concepts like forced displacement into their teaching and research described institutional pressures to focus on more important teaching outputs, stay within their field or prove that the technical rigor of traditional engineering courses has not been compromised when courses are designed to include a degree of interdisciplinarity. The lack of institutional support for courses of this nature disincentivizes their teaching as it often means that instructors must overload their schedule if they wish to pursue such courses out of passion. Regardless of how passionate an instructor might be about the topic, full teaching credit needs to be offered in order to ensure taking on such a course is a feasible and sustainable option for an instructor. Potential means of facilitating this include designing the course to be field-specific (e.g. civil engineering, mechanical engineering, biomedical engineering etc.) and ensuring it draws on specifical technical examples and projects in order to facilitate departmental approval,

presenting the ways such courses can positively impact student retention by showing that courses like these can keep students on the engineering track, and designing transferrable modules within the course which are accessible to and can be adopted by a broad range of faculty members across various departments and disciplines. Anecdotal accounts from faculty, along with research about undergraduate student retention within STEM fields, have shown that students are eager to find connections between and channel their education towards causes they care about and have cited their prosocial desires as well as decontextualized technical courses as reasons behind their decision to leave engineering [17]. Our course model presents an opportunity to fill this gap, allowing students to fulfill their desire to contribute to broader societal challenges through their engineering education and while also helping to keep them on the engineering track.

Student Engagement

In order to motivate and engage students in a course of this nature, there is a need to strike a balance between presenting the scale of these issues in order to awaken a sense of urgency to engage and ensuring that problems are not presented as intractable or unsolvable, leading students to believe their potential contributions can do little to alleviate any of these issues. As discussed, many students are looking for clear opportunities to connect their engineering education to social issues of personal interest and relevance to them, and can feel like their traditional engineering courses are overly theoretical and removed from practical, real-world issues. Thus, empowering students to utilize their technical skills to meaningfully contribute to pressing social issues can be an important motivator for students. At the same time, this element of the course should be balanced with an awareness of the practical, marketable aspects of this training in order to minimize any socioeconomic barriers to such courses. If this aspect is not emphasized and students feel the skills they are gaining are not broadly marketable,

some students who may be interested in these topics may feel it is not practical to pursue this area solely out of passion. Regardless of the field/nature of the course, students are gaining a number of skills which will prove valuable and marketable regardless of where their future takes them. Students should be presented with potential career paths, the language to present these skills on their resumes and in interviews and an understanding that these are in fact marketable skills in the long-term so that socioeconomic factors, which often mean that pursuing something out of passion means making financial sacrifices and is reserved only for the privileged, do not act as barriers to students interested in a course like this one. Formal exams are often not an effective means of evaluating student learning in these types of courses [18]. Students often take more away from assignments when they are given the freedom to take individualized approaches that align with their specific skills and interests. For example, rather than producing a formal report in which they analyze and interpret a dataset related to displacement patterns, students might instead record a podcast which explores displacement patterns, assesses the types of existing data and explores how the availability of data and their representations determine the attention and resources allocated to a given community. Allowing students the opportunity to reflect on their learning through assigned reflection prompts or writing assignments is also useful in courses like this and can also reveal student growth and mindset shifts over the duration of the course. Allowing students to develop a diversity of skills, including communication and writing skills, will allow them to become more well-rounded engineers, which will prove useful in any career they pursue, and better-prepared prospective graduate students. In addition, choosing to focus on case studies which are of local relevance (e.g. migration across the U.S-Mexico border, the displacement of Indigenous communities in the US) may further motivate students to engage

with these issues, by showing them these are not issues that only exist on the other side of the world.

Pilot Course at Boston University: Engineering Approaches for Refugee Health

Following the workshop, in the Spring of 2024, we piloted the course that had been developed at Boston University as a biomedical engineering upper-level elective. The course is an effort to develop a holistic understanding of health of vulnerable, forcibly displaced persons, understand the drivers of displacement, appreciate the contextual realities, develop knowledge of mathematical models to evaluate the risk of disease or burden of infection, critically analyze existing technological solutions from a technical and ethical lens, and design interventions to improve health of these communities. From a structural point of view, the course has three fundamental components. The first is about understanding the context and developing a holistic picture of the issue of forced displacement. This is done through broad-based readings that provide historical, social, ethnographic and ethical context. Additionally, there are interviews and discussions with those who have had lived experience (both in terms of living in refugee camps and those who have worked with displaced communities).

The second component focuses on understanding disease dynamics and determinants of health among forcibly displaced communities, along with a critique of interventions. This component, on one hand, focuses on understanding various mathematical and computational models as well as technologies and system interventions that have been developed to understand and improve health outcomes. Furthermore, this component also includes a robust technical and ethical critique of existing approaches and a discussion of the fundamental reasons why current methods may be inadequate or at times harmful. We discuss not only issues of racism and colonialism, but issues associated with privacy (or lack thereof), the lack of contextual

understanding and the failure on part of engineers and technology developers to fully engage the ethical implications of their work, and both bias and prejudice during technology development and implementation. We also ask questions such as what does the technology actually do, and for whom? Who is the beneficiary? Is it the refugee community or the aid agency? Students also reflect about their observations and analysis through presentations and op-eds in this part of the course.

The third component is to "design" rigorous, context-appropriate and ethically-grounded interventions through group work that focuses on a particular global challenge. The class emphasizes student understanding of not just challenges that are often in the news, but also challenges that are rarely covered in the media. For example, one team will focus on healthcare access among stateless communities in Pakistan, another on the forcibly displaced due to the civil war in Sudan, and another on the internally displaced in Colombia, to name a few. Students will be expected to read broadly, interview those with intimate knowledge when possible, and analyze the trajectory of existing solutions and identify gaps while designing their own intervention. The course (in the current form) does not include actual prototyping or piloting but will focus more on the theoretical design of technological solutions and will focus on both the technical components of that design, its implementation and potential short and long-term impact. It is hoped that the course will eventually include actual prototyping and testing of the technologies in simulated environments.

One key feature of the course is exposure to readings, ideas and approaches that go beyond engineering. Students are expected to read papers and book chapters in anthropology, history, demography and public health (among other areas) to develop a holistic understanding. Some of these readings provide background for the specific classes, others are discussed

explicitly in class. They are also encouraged to seek out perspectives from authors from the community of focus that provide a unique local context. In two informal surveys of the students carried out one and two months after the course started, exposure to readings outside of engineering was highlighted as one of the most useful, insightful and productive parts of the course.

At the same time, students are also expected to develop writing skills and are expected to write two op-eds about their work and why the existing solutions have failed to perform as expected. Students are provided guidance and input on how to craft an op-ed, how to think about the genre of public writing and how this genre is different from technical reports. The first op-ed assignment, due at the mid-point of the course, provided students with an opportunity to reflect on what has changed in their own perspective when it came to forced displacement. Students wrote candidly about how the course has provided them with a much more nuanced understanding of forced displacement, one that is distinct from their previous understanding or what they hear through news and social media. They highlighted, using examples from the course and their own readings, how they have a much better appreciation of the opportunity engineering approaches present, but at the same time, how technology can also increase vulnerability of forcibly displaced communities. They talked about the risk of weaponization of technology for political and economic gains and also questioned global and local policies when it came to technology development, piloting and implementation and the fractured governance structure of technology regulation when it came to refugees and stateless persons.

The homework assignments are divided into two broad categories. The first half of the course focuses on individual problem sets and the second half has design related milestones. In the first half, homework assignments engage students to explore data visualization, gaps in

existing data on forced displacement and its implications, mathematical and predictive modeling techniques, failure mode and effects analysis and health system modeling. The second half focuses on individual milestones associated with design (e.g. problem statement, initial design review, potential bill of materials, risk assessment, failure mode analysis, business model, sustainability etc.)

The limitations of time and resources are an important consideration, and we recognize that we are unable to cover all the aspects to provide an comprehensive understanding of the healthcare challenges faced by forcibly displaced communities, and discuss ethically driven design interventions. Despite these limitations, we hope that the course is able to provide students with an understanding of the health challenges faced by forcibly displaced communities, analyze and reflect on current biomedical technologies and solutions used to address these health challenges, and provide students with ability to identify and develop novel, technically sound, context-appropriate, sustainable and ethical solutions. There is much to learn both from teaching and student engagement and learning. So far, the interest and enthusiasm (both from the number of students who signed up for the course and informal surveys taken regularly after every few weeks) has been extraordinary. Students are excited about the curriculum, appreciate the significance of the material and recognize that this course is able to fill a gap in their knowledge and training. The next few weeks will provide more detailed insight into their overall experience and engagement.

We hope that future iterations of the course will build on the lessons of the first pilot, and will provide students with new knowledge and awareness about the global challenge of forced displacement, while providing them with specific technical skills that will make them more thoughtful, ethical and creative engineers as well as globally engaged and socially conscious

citizens of the broader society. We also hope that our model of designing a broad, interdisciplinary course outline with flexibility to be tailored to meet the needs of different programs helps others to introduce similarly complex topics into their STEM curriculum.

Acknowledgements

The authors would like to thank Ana Deros and Rebecca Everly for their support and valuable insights in the process of planning the March 2023 workshop, course planning efforts and in drafting this paper.

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