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The World of ”Engineering for Good”: Towards A Mapping of Research, Teaching, and Practice of Engineers Doing Good

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Work in Progress Paper

Abstract

Who does "engineering for good"? Where and how do these engineers do good? How are these engineers trained to do this work? And what does it mean to be a successful one? Engineers have provided normative visions for societal change since the profession's conception. A minority of engineers have gone one step further, reimagining and reworking their "desire to help" to begin shaping the networks, programs, institutions and norms that define "engineering for good" today. Engineering for good—or the practice of prioritizing doing good over more traditional engineering urgencies such as cost, technological efficiency, and innovation—has steadily grown in popularity in the United States since the early 2000s. Engineers for good use a variety of language to describe their practice including humanitarian engineering, engineering for development, engineering and social justice, peace engineering, and engineering service-learning. In addition to providing historical context for the growth of this movement, this paper provides an overview of the current academic, nonprofit, and corporate settings in which engineers are explicitly working to do good. This paper begins to reimagine the "community" as the engineers, scholars, practitioners, and networks that are actively involved in defining what engineering for good is by participating in the enterprise. By conducting a preliminary analysis of practitioner-oriented artifacts, networks, scholarship, and their geographies, this paper concludes with the call and an initial sketch for a broad, community-guided mapping of engineering for good's current landscape and potential visions for its futures.

Introduction

This work in progress paper articulates where the "engineering for good" movement came from, provides a brief summary of its current sites for scholarly inquiry and practice, and depicts the motivations and our plans for the future mapping of this movement. While all engineering could be interpreted as an effort to "do good," even indirectly, in our work we are interested in the kinds of engineering that are explicitly dedicated to do good for underserved populations over other goals such as financial profit, national security, technological efficiency, etc. Historical and contemporary background of the engineering for good movement provides both an explanation of the origins of the practice, and motivations for the recent, increased participation in "engineering for good." This contextualization of the practice is important for our description of the current field. We contextualize the field of engineering for good to best describe how and if participants' efforts are connected. For this regional ASEE meeting session, we focus on "engineering for good" based within the United States as a small case study, however, our research team has plans to do more expansive mapping of engineering for good within North America and Latin America in the near future.

We propose a future community-based mapping of engineering for good programs and initiatives to identify common themes, resource management strategies, and potential partnerships and networks. Community-based mapping strategies allow programs' participants to contribute to the mapping of engineering for good and benefit from the mapping of their and their partners' networks. While we appreciate the use of systematic literature reviews as means to map a field or discipline, this project hopes to enroll participants beyond those that publish in the field to include those that practice, teach, promote, and organize engineering for good [1].

This mapping will serve complementary purposes of a traditional literature review. Authors Borrego et al [1] provide justification and motivations for a systematic literature review in engineering education or other interdisciplinary fields. These scholars describe how many of the justifications for a thorough literature review are shared with our proposed mapping strategy—tracing historical development, describing state of knowledge or practice on a topic, and evaluate or develop theory (pg. 49-51 in [1]). This project aims to engage relevant engineering for good scholarship, while also staying attuned to practitioners' interests in its findings. This emphasizes one of the aforementioned justifications for literature reviews, namely "describing the state of knowledge or **practice"** of any given field, in our case, engineering for good, but we argue that our mapping of engineering provides something new and different. This form of critical participation within academic settings is an example of "scalable scholarship," or tempering critical engagement with engineering with accessible scholarship [2].

We propose that while a literature review of the field of engineering for good is a critical piece of this mapping project, it does not fully describe the engineering for good network. This mapping project hopes to connect the engineering education scholarship dedicated to engineering for good to non-academic, professional, and volunteer networks and practices. One of the mapping categories, as described below, will be a bibliometric network analysis of the scholarship. Our goal is for this bibliometric network analysis to serve as a launching point for other forms of networking, for an example of how these networks can track the evolution of an interdisciplinary field or how they make visible interinstitutional coalitions that support larger efforts of engineering for good see [3].

The full project will use a mixed-methods approach. First, we will map networks of engineers, and their educators, engaged in producing scholarship about engineering for good practice through quantitative bibliometric analysis (i.e.[3]). This research will also describe both the professional and volunteer networks of opportunities for engineers for good through a variety of qualitative data collection methods such as participant observation of a series of focus groups with actors identified in the bibliometric analysis, followed by semi-structured interviews, and surveys, polling relevant actors in this field of inquiry and practice. Combining both the bibliometric and the qualitative data collection methods, this work deploys a modified Actor Network Theory (ANT) analysis on the field of engineering for good [4]. ANT provides a theoretical framing for depicting networks of practice, not just scholarship in a particular area of engineering education. In so doing, this project aims to provide useful maps of an emergent field and also develop new methods for mapping engineering practice.

Background and Motivation

Within the United States, engineers are fundamentally tasked with being in service to others. The first canon of the National Society of Professional Engineers Code of Ethics commands that engineers shall "hold paramount the safety, health, and welfare of the public [5]." However, market demands mostly from for-profit corporations and military contractors, and unique labor practices, have made engineers shift priorities away from the public to emphasize adding value to corporations and/or contributing to national security by building weapon systems [6, 7]. At the inception of engineering professional societies in late 19th and early 20th century, before the creation of the large corporations that emerged out of the Gilded Age, engineers were at the service of nascent nation-states, focusing in the creation of transportation and public-service infrastructures [8, 9]. After a brief period of relative professional autonomy and searching for the soul of the profession [10], engineers came to be primarily in service to corporations after the New Deal, and later of the military-industrial-academic complex during the Cold War. Corporate and government locations and loyalties distanced engineers from those that will use and be impacted by the technologies that they design and produce. The end of the Cold War, the systemic reforms in international development of the 1980s, and the rise of sustainable development in the 1990s brought increased international attention to the linkages between poverty, environmental devastation, and the diminishing role of the State ([11], chap. 2) These significant geopolitical shifts, in addition to the dislocation of engineering employment [12], the increase of media coverage of humanitarian crises, and the call for globalization of engineering education, gave rise to the engineering for good (EfG) movement in the late 20th and early 21st centuries [13]. While there have been earlier attempts in engineering for good, such as the creation of the Volunteers in Technical Assistance Network in the 1950-60s [14], the scale and visibility of the new movement have no precedents in US engineering education and practice; hence our desire to map this significant phenomenon.

The EfG movement became popular alongside professional engineers' desires to rewrite their relationship with corporations [15, 16]. As historian Matthew Wisnioski details in his book *Engineers for Change* [17], a small but vocal minority wanted the engineering profession to be more accountable to the general population over their employers, rebelling against corporate constraints and prioritizing progressive change in the "long sixties." This direct rewriting of the relationship between engineers and their employers [12], along with increased portrayal of global humanitarian crises and efforts [11], and calls for globalization of engineering education, paved the way for the formation of engineering for good. Contemporary language and conceptions of "good" have greatly impacted engineering for good practice and the acceptable communication of what doing good through engineering can mean. Since these revolutionary beginnings, the field of engineering for good has spread and in turn, been critiqued, institutionalized, codified, transferred across national boundaries, and reworked, evolving into different practices given unique institutional and individual contexts [13, 18].

Since the founding of Engineers Without Borders-USA in 2002, there has been a dramatic increase in engineering for international development pedagogy and practice [11, 19]. EWB-USA chapters have increased from 1 in 2002 to more than 235 in 2021. Traditionally, these efforts are small in scale, focused on common global development efforts like access to water, sanitation, and best hygiene practices (WASH), shelter, or foot bridges. While these projects are most readily conducted by student and professional volunteer groups, this practice has original roots in the work of rebellious, change agents. These international development efforts of the early 2000s were reformulated versions of the appropriate technology movements of the 1960s, [14, 20]. But now, their popularity has increased, with significant student mobility around the world, that became possible after the end of the Cold War, leading to the globalization of engineering education [21]. EWB-USA revitalized the “appropriate” solutions model, one that aims to both draw on previous technical projects for inspiration in small, community development projects, but also tailors those solutions to individual projects [22].

Engineering for good efforts have spread and diversified. Each initiative prioritizes different forms of “doing good” in their research, teaching, and outreach.[i] Some programs highlight the need to complement engineering with humanities and social sciences, while others emphasize empathy and humility, and others provide clear disciplinary standards for successful sustainable community development projects [11]. Others focus on particular areas of technical expertise, like WASH and civil engineering described above, Information and Communication Technology (ICT), or renewable energies like IEEE Global Humanitarian Technology Conference, which focuses more on technological development than process. Others center social justice as core to their work, efforts, and ultimate goals [23]. These priorities are not mutually exclusive and therefore expertise of any one emphasis could be valuable to other engineers for good.

One defining feature amongst all the programs and practices that this project will map is that all initiatives prioritize “doing good” over traditional motivations for engineering such as capital gains, innovation, or cost efficiency [16, 24]. Engineers for good, however, learn and work in institutions and organizations that have been historically co-constructed with these traditional engineering norms. In turn, this co-construction shapes what engineering expertise is by favoring the corporate bottom-line and standardized conceptions of “rigorous” engineering practice [25]. For example, particular areas of engineering expertise are popular because they were at one time prioritized in commercial markets and military applications. Engineering for good claims to be different [26, 27]. Engineering for good efforts critique and rewrite engineering expertise as much as they carve space to develop new practices such as sustainable community development and peace engineering [11].

These rebellious engineers have a lot to learn from each other but first they need to understand how they are positioned with respect to one another. A thorough mapping of their practices could engage a broad audience of like-minded engineers that may have only bifurcated because of their disciplinary and institutional positionality. Engineers' good intentions and their "desire to help" have created robust educational programs, yet scholars question engineering for global development's ability to actually improve the human condition [13, 28]. Post-development literature claims that these humanitarians could be doing more harm than good through neocolonialism power relations [29, 30]. In addition, others ask whether these efforts are intended to benefit students as much, if not more, than the intended community-benefactors [31]. In response to some of these concerns, some engineering for good initiatives, like Ingenieros sin Fronteras-Colombia, have made a concerted effort to stay domestic and interact with communities with whom they have deep knowledge, understand the language and culture, and developed trusting relationships. How many of these efforts exist in the US? How can these inform those who have not taken a critical stance of their international work?

Preliminary identification of educational programs engaged in engineering for global development (EGD) has been started by one of our research partners, Engineering for Change (E4C) [19]. Our mapping research aims to build on E4C findings in two major ways, 1) we will map relevant university partners as part of (but not the complete) network, including NGOs, religious organizations, and corporate opportunities (including explicit corporate social responsibility (CSR) efforts) involved in the creation and sustainability of engineering for good and 2) expand our definition of "engineering for good" beyond global development to include areas like health as exemplified by Engineering World Health, engineering and social justice, and peace engineering.

With regards to the first mode of expansion listed above, our research will still include university partners and education programs in our mapping, as they are important sites for engineering for good practice, but this research aims to situate the formation of engineers for good into a larger context of professional and volunteer practices [32]. This research also aims to expand "engineering for good" beyond "engineering for global development." As described above, engineering for good was first and primarily remains about community engagement in international development contexts; this research aims to make space for more inclusive definitions of what practices will be included in the mapping of engineering for good. While the field has its roots in academic fields like post-development scholarship and engineering studies, this mapping research welcomes others which include a wide spectrum of engagement with this critical scholarship from: those that may not be exposed to these classic critics of engineering practice and others at the other extreme, whom the critiques of traditional practice has prevented them from participating in engineering for good because of the desire not to inflict neocolonial and structural violence which these post-development critiques warn against [29, 30].

In some programs, engineering for good has expanded to include local, social justice efforts with specific project targets in mind like homelessness, food deserts, systemic racism, etc.; along with continuing to include engineering service-learning, engineering for global development's predecessor (i.e.[33]). Mapping service-learning and social justice efforts within the United

States allows for unique exchange and learning, as often engineering and social justice remains siloed, for example, from service-learning. Including both of these categories as a part of the mapping of “engineering for good”, would allow for participants of each to see how they are positioned with respect to each other, allowing for exchange of ideas between a wide variety of categories of engineering pedagogy and practice.

The work directly contributes to the conference's theme, *Developing Humanitarian Engineers*, as it will provide both academic and practitioner-oriented research that will aid in the teaching of engineers for good. It aims to create common understanding across programs, if for no other reason they will be included in the same, umbrella category for this research. This research directly contributes to current engineering education research, and one of the proposed focus groups will take place amongst prominent engineering education scholars interested in engineering service and “doing good”, which advances both the Liberal Education/Engineering & Society (LEES) and Community Engagement ASEE division charters.

The proposed focus groups will serve as a launch point to collect data about defining community-based mapping as defined by groups of engineers engaged in doing good. We anticipate that this redefinition may be uncomfortable for some engineers who rarely see themselves in need of mapping their own knowledges, practices, assumptions, and locations. But, we believe this reorientation will reframe conversations with regards to expertise and knowledge that engineers for good have, to helpful knowledge of their networks that they possess and would be helpful to others. This research aims to fulfill those needs. The focus groups will be a place for the research team to learn from engineering educators and practitioners about what kinds of mapping would be helpful to them, in addition, the focus groups will leverage participants’ descriptions of their own networks as a starting point for the following mapping exercises.

Mapping these efforts will unlock further potential for collaborations. A clear explanation about what commonly used language means (e.g., community engagement) could bring new meaning for participants and draw those interests together, uniting under common goals. These programs could more clearly and effectively organize to earn disciplinary power and legitimacy, promote some semblance of solidarity, and perhaps view ourselves as a united field, launching a movement that could bring reform to engineering education that thus far has proved elusive. However, promoting change within or as a part of engineering is an act of rebellion. Engineers within the United States have been trained to thrive in a “culture of disengagement,” a professional norm which elides the political nature of technology development and encourages engineers to thrive in a state of detachment and apathy, particularly with regards to civic engagement and social reform [34].

Methods and Mapping Categories

Following extensive bibliometric mapping, our research group will conduct a preliminary mapping of both additional professional and volunteer opportunities through online research into the wide variety of engineering for good efforts within the United States. As previously stated, a preliminary identification of educational programs has been completed, with other relevant documentation provided by relevant conference organizers of events our research team has already attended. A thorough review of literature and public-facing material which articulates a connection between these otherwise disparate fields will be conducted. This project aims to bridge the intellectual and practical gaps between groups of engineers for good, who ultimately have similar goals, but they do not know how to communicate with each other. Beyond these literature reviews, participant observation of the proposed workshops, survey results, and snow-ball interviews will provide the qualitative data needed to clearly articulate what engineering for good efforts exist. Anecdotally, we know that these programs are connected through shared literature and shared visions for the future of their programs, and we believe that clearly mapping relevant actors will bring some clarity to the connections for practitioners and academics alike.

The qualitative data collection will start in earnest with a series focus groups held over the course of 2021. We hope to enroll engineering education participants in thinking through how to best learn from their networks of engineering for good for this mapping process. Our research team will be working with two part-time Engineering for Change (E4C) Fellows, that are being funded to work on the mapping of engineering for good research. The fellows, along with the research team (and authors of this paper) will prepare for the focus groups and then synthesize the findings, making plans for follow-up data collection in the form of surveys and interviews. After data collection in the remainder of 2021, the research team will publish the project's findings and translate the mapping exercise to publicly accessible formats: i.e. job and volunteer boards, open-source reports, literal maps etc.

Mapping categories

Scholarship. Quantitative bibliometric data mapping allows for engineers for good to see relevant scholarship in their area of expertise. While popular texts are shared amongst certain types of engineering for good (see [11] for a good example in engineering and community development), we are unaware of how (if at all) this scholarship travels beyond its sub-category of engineering for good. We also want to know if and how EfG scholars use non-EfG scholarship such as critiques of development and participatory methods (i.e. [29, 30]) or science and technology studies (STS) literature that allows them to see technologies as socially constructed. For example, do EfG programs produce a different academic profile by engaging these different literatures? Do the students of these programs become more critical thinkers than doers after engaging with these literatures? Or do these students become "critical doers" after synthesizing the critical literatures with field practice (praxis)? Do these academic profiles blur as these engineers for good go out and develop their professional and volunteer lives? Ideally, these bibliometric maps will show influential scholarship within each sub-field, but also ways scholars are bridging the gaps between them.

Interdisciplinarity. After networks of scholarship have been mapped, the relevant authors' disciplinary positionality will be mapped. This will connect the types of scholarship that are produced in and for engineering for good to the profiles of the people engaged in developing this scholarship. Mapping the disciplinarity of scholars is the first step of developing metadata of the network, working to connect scholarship to other volunteer and professional opportunities. These scholars are critical actors in defining and sustaining engineering for good. Once the disciplinarity of these individual authors is clearly depicted, we aim to show how engineers for good engage in interdisciplinary training. This interdisciplinarity will be important to the kinds of modes of criticality that engineers for good are engaged in, in different contexts.

Modes of Criticality. Our research also hopes to map how engineers for good are engaged in critically assessing their own involvement in traditional engineering practice, international development, and social justice. Each of these fields of critical inquiry have their own scholarship. This scholarship includes the critical examination of "otherness" between engineer and community member, neocolonial and post-development critiques of international engineering, and the practical criticisms of the limitations of promoting social justice within engineering. It takes an interdisciplinary training to engage in these different critiques.

Professional opportunities. Engineering for good can also take place in corporate settings. Mapping of professional opportunities will serve as a place to develop open-access practitioner-oriented tools to display our research findings. This mapping, far beyond the other categories, will directly impact engineers for good in their professional development and next steps in their careers. But, the mapping of these professional opportunities serves a dual role. Alignment between academic offering and professional opportunities is ideal, if not essential. Directly mapping these efforts, in connection to academic research and teaching programs, will show faculty how their engineering formation is or is not leading to career satisfaction. In other words, is there alignment between what engineers for good want from their careers versus how they are being trained in their academic programs?

Volunteer opportunities. Mapping relevant volunteer opportunities will probably provide different outlets for engagement of engineers for good. These opportunities include volunteer opportunities within companies, i.e. when companies allow employees to work on "passion projects" regularly, which can (among many other things) include company-wide development efforts or it can include volunteering for an EWB-USA professional chapter. These opportunities can also include volunteering for religious or social justice organizations where engineers can make their religious and/or political values more explicit and overt than when at work. Mapping these volunteer opportunities will bridge the gap between academic and professional engineering for good opportunities. This work will be especially advantageous for engineers for good who want to pursue a "traditional" engineering path, but also want to continue to engage in engineering for good alongside their professions.

Conclusion

While we have laid out a variety of potential mapping strategies, we welcome critical feedback in response to our plan. We plan to continue this work in the long term, working to map EfG efforts in the United States and Canada within the coming months, leading up to a larger event at Colorado School of Mines in 2022 for a peer review of our mapping process and results. We hope this future event will serve as a collaborate space for community members to provide feedback and draw attention to gaps in our mapping research. We understand this mapping research is ambitious, but we think it is vital for the success and solidarity of the sub-fields within engineering for good.

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[i] "Engineering for Good" is not used by these engineers, and therefore is used as an analyst category. Humanitarian engineering, engineering for global development, among others, are more common among practitioners.