Background and Design of a Qualitative Study on Globally Responsible Decision-Making in Civil Engineering

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***Abstract**: Organizations that regulate civil engineering have been pressing for integration of 'global responsibility' into higher education curricula since around 2006, with a goal of achieving environmental sustainability and social justice. In an effort led by the American Society of Civil Engineers (ASCE, 2007, 2009), a global vision for civil engineering was identified. Within the UK, the Institution of Civil Engineers (ICE) has been leading the way alongside non-governmental organizations (Bourn & Neal, 2008). Via the in-progress study reported here, a UK-based research team is now studying the effects of ACSE and ICE initiatives. The team seeks to benchmark how global responsibility is perceived and enacted in civil engineering in the UK today and how engineering graduates have learned about and experienced globally responsible decision-making. Findings will hold value for the global community, as achieving sustainability is crucial to humanity, and indeed all life on Earth.*

Introduction

Today, a university-based engineering education research team in the United Kingdom is partnering with Engineers Without Borders UK (EWB-UK) to conduct an exploratory study on engineers' perception of global responsibility with regard to engineered environments. This topic was proposed for study by Engineers Without Borders UK, with a long-term objective of achieving globally responsible decision-making across engineering fields. Findings will hold value for the global community, as achieving sustainability is crucial to humanity, and indeed all life on Earth. This paper describes the team's work-in-progress and serves as an example for other researchers regarding how to design similar projects in their own contexts.

The project is founded in the belief that environmental and social sustainability must be embedded into engineering education and engineering practice such that engineers can make better decisions day-to-day. This exploratory study grew out of three preliminary questions raised by EWB-UK: (1) To what degree are environmental, economic, and social sustainability valued in the practice of engineering? (2) To what degree are the values of environmental, economic, and social sustainability embedded in the practice of engineering? (3) What opportunities and barriers exist regarding global responsibility in engineering practice? EWB-UK had proposed the idea for this exploratory study to the UK's Royal Academy of Engineering (RAEng) which agreed to support the project financially. Having the skills to conduct valid and reliable empirical research, researchers at the Centre for Engineering Education at University College London (UCL) were enlisted to produce the study, and a focus on civil engineering was mutually agreed upon for exploratory work.

Short-, medium-, and long-term objectives were identified. Short-term objectives are to: (1) identify and understand definitions and goals developed by leading organizations in the realm of global responsibility and engineering; (2) generate understanding of civil engineers' day-to-day experiences, identifying how they learn and integrate knowledge of global responsibility; (3) produce findings that help benchmark how far the civil engineering profession has travelled and how far it might have left to go to achieve stated goals; and (4) identify implications for research, engineering practice, and engineering education. A medium-term objective is to help increase the rate of change and enhance overall success in civil engineering projects. A long-term objective is to help increase global sustainability across multiple sub-fields of engineering.

At its core, however, this study focuses on the interviewees' experiences and their understandings of global responsibility. EWB-UK, the RAEng, the UK's Institute for Civil Engineering (ICE), and the American Society of Civil Engineers (ASCE) have all contributed literature to assist in understanding the topic, but in this study, the research team does not define the term for interview participants. Participants are first asked about a time they made decisions in the realm of global responsibility, and near the end of the interview they are asked to summarize their personal definition of global responsibility. This sequence is intended to help the research team identify what topics resonate with participants—which concerns stick in these engineers' minds—and ultimately influence their work and the buildings and infrastructures they produce.

Today, an exploratory study is well underway. It began with collecting data via personal interviews with nine individuals who work in civil engineering and allied fields. Although the size is small and cannot answer all questions EWB-UK and the RAEng have, the size is appropriate for exploratory study and consistent with many other studies involving analysis of in-depth interviews. Participants have been recruited via Tweets and email blasts from Engineers Without Borders UK, based on criteria agreed with the research team to yield maximum variation in responses. At this exploratory stage of research, which may be expanded later based on findings that emerge, grounded theory is the primary research methodology being used. Grounded theory is an optimal methodology for use in exploratory work (Savin-Baden & Major, 2013). Applying a lens of environmental sustainability further focuses the study, via a theoretical framework involving: (1) the UN's Sustainable Development Goals (SDGs); (2) the concept of the three-legged stool seeking to balance concerns of environmental, social, and economic sustainability (see McDonough & Braungart, 2010), and (3) Raworth's (2017) doughnut model depicting social and planetary boundaries. Interview data are being collected such that they will be appropriate for phenomenographic analysis in subsequent stages of the project, following initial analysis and interpretation, and collection of additional interviews. The primary value of this conference paper, however, is to researchers interested in designing similar studies and/or in discussing global responsibility at the Research on Engineering Education Symposium (REES).

Context

This work builds upon a solid understanding of social and environmental principles underlying and extending the Brundtland Report (Hauff, 2007) including *Cradle to Cradle* (McDonough & Braungart, 2010) approaches to *Worldchanging* (Steffen, 2008), and ways of encouraging, facilitating, and assessing progress (British Standard Institute, 2013; Chance, 2010, 2012). It also draws from emerging economic (Kelly, 2012; Rifkin, 2011; Rockström et al, 2009; Steffen et al, 2015) and regenerative models (e.g., Iverson & Chance, 2007).

The Royal Academy of Engineering has been supporting the development and distribution of educational tools and techniques to promote understanding of ethical issues among graduate engineers (Bourn & Neal, 2008). As a result, more and more young professionals are entering the practice of engineering with awareness of global responsibility and heightened understanding of the role engineers can play. The RAEng emphasises the urgent need for engineers to provide leadership in addressing environmental and social issues in the day-to-day aspects of their work. A hope is that the incoming generation of engineers can advocate for and enact change, infusing new knowledge into the profession. Although many graduate engineers have learned about ethics and are now under pressure to enact these values, they may not, however, have the professional standing and/or mastery of techniques needed to actually implement change.

The RAEng has interest in tracking results, and the organization provided seed funding to support exploratory work. An outline proposal was made by EWB-UK, and the organization later enlisted a team of experienced researchers to conduct the work. Together, the lead researcher and a team of expert advisors appointed by EWB-UK brainstormed relevant issues and framed the study; this steering group considered what problems engineers encounter when putting ‘global responsibility’ into practice, and how engineers balance their duty to ‘avoid harm’ on the one hand, with the duty to ‘do good’ on the other? More specifically, the steering group wondered, how do practicing engineers deal with commercial pressure and ‘value engineering’ when such pressures appear to be at odds with concerns for environmental or social justice?

A literature review is being conducted to provide background context. To date, literature has been reviewed and an annotated bibliography has been created. Those data will be synthesized soon, as results are derived from the empirical interview data and findings are distilled. In essence, the literature review is identifying the ‘who, what, when, where, why and how’ aspects of global responsibility and applying several different philosophical lenses to explore deeper underlying issues such as ethics, professional obligations and duties, and economic and political constraints. Aims of the literature review have been to distill shared understandings of ‘global responsibility’ that exist in engineering today, identify how leading organizations intend to achieve it, and explore philosophies underpinning the overall concept. A short overview is provided below to introduce REES readers to the topic.

“The sustainable development concept requires of all of us—as engineers and citizens—to consider much more widely than before the impact of our own lives and of the infrastructure and products we produce, both geographically and temporally” (Broers, 2005, p. 3). This is coupled with the belief that, “Through the application of science and engineering, humanity has the potential to meet all of its basic needs: water, sanitation, food security, shelter, energy, transport” (Bourn & Neal, 2008, p. 2).

The American Society of Civil Engineers (ASCE) led development of the vision statement that is most prominent across civil engineering world-wide. In June 2006, sixty thought leaders from around the globe—representing all career levels and having highly varied backgrounds—convened to define a global vision for civil engineering (ASCE, 2007). With this *Vision for Civil Engineering in 2025*, the members of this profession would lead global change as “master (1) planners, designers, and constructors; (2) stewards of the natural environment; (3) innovators and integrators of technology; (4) managers of risk; and (5) leaders in shaping public policy” (ASCE, 2009, p. 5). The statement offered “a bright,

ambitious goal [to] guide civil engineers around the globe [to] help achieve a sustainable world and raise the global quality of life [by embracing] a new level of leadership and responsibility for the global engine of societal betterment—the built environment" (ASCE, 2009, p. 9). It was noted that "Ultimately, only a few civil engineers may master all aspects of the Vision individually, but as a body of professionals, civil engineers should be viewed as mastering all that the Vision encompasses" (ASCE, 2009, p. 10). Although ASCE led the effort, this "was never intended as an ASCE or United States initiative" and the issues and goals identified are "not specific to any nation, culture, organization, sub-discipline, or practice area" (ASCE, 2009, p. 14).

After assessing who defines the term and the vision and strategy for achieving it, the literature review assessed what is meant by global responsibility across: (a) the engineering professions globally, (b) civil engineering, and (c) buildings. It looked at the past legacy of leadership in global construction across the profession of civil engineering, and the present situation, including current skills set of practitioners and the profession's current focus on educating engineering students as agents of change. As Bourn and Neal (2008) explain, "engineering is a global industry. To be a global engineer requires not only understanding the global context but also recognising the contribution engineering can make to securing economic and social change" (p. 5). The effect of interconnected scales, systems, and decisions mean this is an inherently global topic.

Civil engineering has taken this global perspective seriously. In the UK, the Institute of Civil Engineers "was founded in 1818 […] the first engineering institution in the world" (Leiper, 2006, p. 3). And globally, "Civil engineers are rightfully proud of their legacy. During the past century, [via] clean water supplies […] Transportation systems […] bridges […] Towers […] the largely hidden water supply and sanitary sewer systems, civil engineers have made their mark in many aspects of the daily life of essentially everyone around the globe" (ASCE, 2007, p. 3).

The RAEng has provided workshops and tools for engineering educators across multiple sub-fields to develop mastery in teaching these subjects. The most prominent of these efforts is documented in Bourn and Neal (2008), whose publication "aims to provide UK engineering faculties and higher education institutions (HEIs) with practical guidance on incorporating global issues and sustainable development within the engineering curriculum" (p. 4).
In the USA, the ASCE's (2009) strategy provides a roadmap in that it "proposes 24 supporting outcomes and more than one hundred tactics. [and] more detailed action steps" (p. 14). According to ASCE (2009), realizing the vision means that:

> *First, the global civil engineering community must broadly embrace the Roadmap […] Civil engineers around the globe must be informed, educated, and recruited to help achieve the Vision, and bring to the fore key issues for stakeholders. Finally, the whole effort must be monitored, evaluated, and measured over the long term, with course corrections made along the way. Such a broad activity set will not be centrally controlled […] In the end, the common, unifying driver will have to be the Vision, and the Roadmap to achieve the Vision. (p. 7).*

The current study grows from Bourn and Neal's (2008) recommendation for "Professional and research bodies to support further research on the impact and value of the 'global engineer' concept in the contribution of engineering to positive world change and meeting the skills needs of the UK workforce" (p. 3).

In conducting the literature review, the research team has been making effort to identify and assess underlying philosophies of 'global responsibility'. They have looked at topics involving duty and morality (ranging from mandatory duties to actions that would be praiseworthy, but not required) and they considered duties to do good and the duty not to harm, as well as anti-corruption laws and practices. They questioned where responsibility lies (by considering

collective responsibility, how to impart values, and patterns and parameters of collectivising within the engineering profession in the UK). They considered obligations (special and professional), as well as economics (ranging from capitalism and free market ideology, to the place of engineering and technology within our economy), and the role of politics in the professions.

Research output

At the end of the exploratory phase of this study, the university-based research team will provide a research paper. Using this, EWB-UK will produce a formal report to help educators as well as students and the employers receiving them. Overall, this study aims to address intentions stated by the RAEng to promote focus on environmental, economic, and social sustainability in engineering practice as well as education. This is part of the Academy's larger objective to increase the uptake of globally responsible decision-making, particularly with regard to environmental sustainability and social justice. This research is important to engineering education because educators aim to prepare students to identify, address, and solve global challenges. Understanding what graduate engineers have learned in university and then in practice, and how they experience decision-making in this realm are important.

Research questions

Data collected to date indicate the research team will be able to determine:

- In what ways do civil engineers in the UK understand 'global responsibility'?
- In what ways do they experience decision-making with regard to global responsibility?
- To what degree are environmental, economic, and social sustainability valued and enacted in engineering built environments?
- With regard to global responsibility in engineering practice, what opportunities and barriers do participants describe?

Theoretical frameworks

As noted above, the theoretical framework for this study incorporates the globally-recognized SDGs along with the 'three-legged stool' (McDonough & Braungart, 2010) and Raworth's (2017) doughnut model of social and planetary boundaries. This study seeks to understand if and how civil engineers balance competing concerns in their work today. At the most simple level, an appropriate balance can be visualized as the three-legged stool, with legs representing concerns that are: (1) economic, (2) environmental, and (3) social (McDonough & Braungart, 2010). At a more advanced level of conceptualization, Raworth's (2017) doughnut model may also apply (see Figure 1) because many of the terms included in her model are applicable within civil engineering. Civil engineering relates to current shortfalls in housing, networks, energy, and water at the most obvious level, but can also be linked to shortfalls in food, health, education, income and work, peace and justice, political voice, social equity, and gender equality. Decisions civil engineers make have direct implications for current overshoot of the ecological ceiling in all areas on Raworth's model: freshwater withdrawals, land conservation, biodiversity loss, air pollution, ozone layer depletion, climate change, ocean acidification, chemical pollution, and nitrogen and phosphorous loading. The key to providing 'safe and just space' for humans lies, according to Raworth's model, in creating a regenerative and distributive economy. Thus, the research team also will be able to identify:

- Which aspects of Raworth's model have been articulated by civil engineers in the sample group?

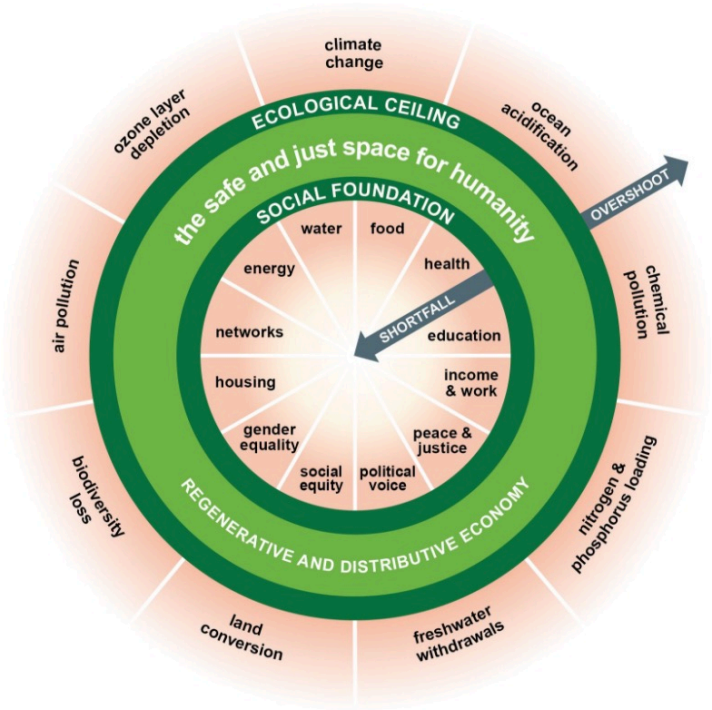


Figure 1: Doughnut of social and planetary boundaries. Source: Raworth (2017)

EWB-UK has embraced the UN's Sustainable Development Goals as core principles guiding its efforts (see Figure 2) and the team will also consider which of the SDGs figure prominently in interview narratives.

Figure 2: Sustainable Development Goals. Source: United Nations (2015)

Methodology

In the exploratory phase, the research team is using grounded theory methodologies. This involves the type of thematic analysis (e.g., involving open, axial, and selective coding) defined by Strauss and Corbin (1994). NVivo 12 is being used for data management and the project was approved by UCL's ethics review board. By using grounded theory, the research team aims to: (a) identify patterns; (b) describe implications of these patterns; and (c) generate recommendations for engineering education, research, and practice. This is a topic of great interest to the Royal Academy of Engineers—they want to hear the voices of practitioners and understand what barriers keep engineers from realizing their full potential to positively affect social justice, climate change, and the like. As such, grounded theory is an ideal method and will be used at stage one.

To ascertain differences in the way individuals experience and conceptualize things—such as global responsibility, environmental sustainability, social sustainability, and personal and professional responsibility—individual interviews are often collected. Discussions with individuals are seen as more effective than those conducted in focus groups when diversity of opinion and/or perspective is sought. Bruce (1994) explains that in situations where there are multiple interviewees, participants tend "to move towards positions of agreement rather than diversity" (p. 53) and differences in their ideas are more difficult to identify. To address the stated research questions, the researchers have aimed to collect data via personal interviews with nine individuals who work in civil engineering and allied fields.

To date, all but one participant has been within ten years post-graduation; the sample group reflects a wide variety of job focus (design, site operations, cost estimating, theoretical and applied research, and management). The data collected are appropriate for analysis using phenomenography as well as grounded theory. Collection of additional data in the future may facilitate more specific analyses (phenomenography requires a minimum of 20 participants and far more time than available under the current funding model). In future sampling, the team will aim for even greater diversity of interviewees, with regard to their project roles (i.e., client, graduate engineer, directing role, or management role) as well as focus (i.e., stages of Design, Construction, Commissioning and Operations, and Demolition or Renovation). However, for an exploratory study, grounded theory is appropriate and will help the team define appropriate questions, theoretical frameworks, and methodologies for additional work.

Consistent with established methods of both grounded theory and phenomenography (Åkerlind, 2012; Ashworth & Lucas, 2000; Bruce, 1994; Marton, 1986), the first and second author on this paper conducted semi-structured, phenomenographic interviews that were conversational in nature. Interviewees touched on topics such as carbon footprint, material consumption, transportation and logistical efficiency, emergence of new technologies, social equity, familiarity with the UN's Sustainable Development Goals, and pro-bono/outreach/ volunteer work.

Interviewers prompted participants to identify and describe their own concepts of 'global responsibility' rather than presenting any *a priori* description of 'global responsibility'. Questions focused on participating engineers' experience of dealing with issues of global responsibility, asking participants to provide details about specific occurrences rather than general/abstract impressions or conceptual ideas. This was intended to shed light on problems that engineers have faced in trying to implement their ideals in practice, and what they have found to be stopping them.

Interview questions

The following interview schedule guided the collection of empirical data.

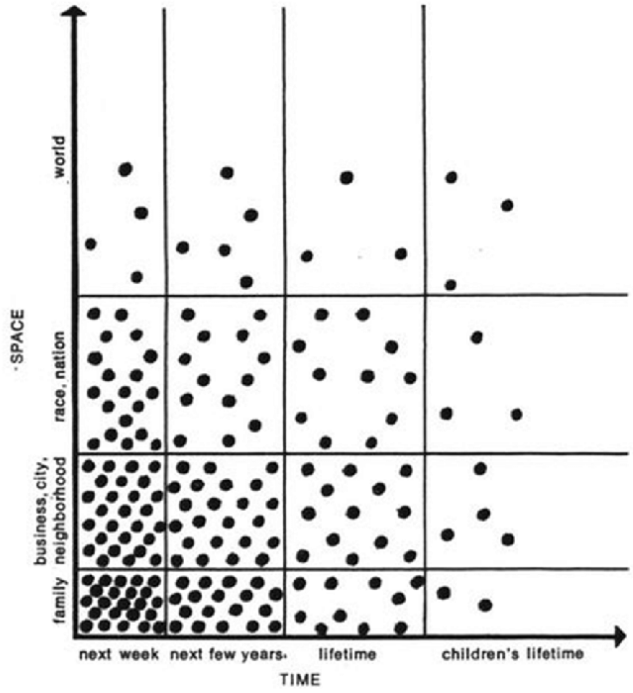
1. Please tell me about an instance in your recent work as a civil engineer where you made decisions related to 'global responsibility'. *Probe any of the following, as appropriate*:
    - WHAT happened?

- WHAT was the context of the experience?
- WHO was involved?
- WHEN did this happen?
- WHERE did this happen?
- WHAT influenced your decisions?
- WHY did that topic matter to you?
- WHAT was the outcome?
- HOW did you see 'global responsibility' relating to that situation?

2. HOW did you learn about global responsibility?
    - WHAT stage are you at in your career?
3. WHAT attracted you into civil engineering?
4. With regard to global responsibility:
    - WHAT barriers have you faced? Anything particularly stressful or corrupt?
    - WHAT opportunities do you see?
5. You mentioned earlier that you… [faced a specific challenge]. What prior experiences helped prepare you to meet this challenge? *Probe any of the following, as appropriate:*
    - HOW did you learn about that [topic you mentioned]?
    - HOW did that affect your decisions?
    - HOW did you resolve that?
6. At this point, can you please SUMMARIZE how you define 'global responsibility'?
7. Do you have any other examples of times you considered 'global responsibility' in your work?
8. Before we conclude, is there anything you would like to add that you haven't had a chance to talk about. *Probe: Is there anything else you'd like to say, for example, about…*

Conclusions

To date, the team has collected a wide range of descriptions from participants regarding their experiences and ideas of global responsibility. The data are indeed appropriate for both grounded theory and phenomenographic analysis. However, there are limitations to the current dataset due to small size and the fact that participants were recruited via email blasts originating from EWB-UK. While not all participants are EWB-UK members, the sample is somewhat skewed. People near the UCL campus and comfortable enough to discuss an ill-defined topic (advertised as 'global responsibility') signed up to participate. If the study is expanded, we may work to recruit a more diverse group with people not connected to EWB-UK. By the time of presentation in Cape Town, the team will have identified themes and be able to share findings via an A4 handout including implications for engineering education. Based on themes emerging from initial coding, we believe that the conceptual framework provided by Meadows et al (1972) (see Figure 3) may be valuable as a lens for interpreting results.



Although the perspectives of the world's people vary in space and in time, every human concern falls somewhere on the space-time graph. The majority of the world's people are concerned with matters that affect only family or friends over a short period of time. Others look farther ahead in time or over a larger area—a city or a nation. Only a very few people have a global perspective that extends far into the future.

Figure 3: Human perspectives (source: Meadows et al, 1972, p. 20)

This way of analysing the world can complement the Raworth (2017) framework and any analyses conducted to identify overlaps between narratives and the United Nations (2015) SDGs. In combination, these three frameworks can serve as lenses for reading data through and the process can generate new understanding of the narratives provided by interviewees.

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