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Volunteer Professionals in an Undergraduate Design Challenge: Contributing to and Practicing Globally Responsible Engineering

Bryce Neuman[a] and Jonathan Truslove[b]
Technical University of Munich[a], Engineers Without Borders UK[b]
Corresponding Author's Email: jonathan.truslove@ewb-uk.org

ABSTRACT

CONTEXT
The Engineering for People Design Challenge is an innovative programme coordinated by Engineers Without Borders UK and Engineers Without Borders South Africa with the aim of developing globally responsible engineering graduates. The programme prompts students to develop engineering solutions to social problems within a broadly framed real-world context. The programme is squarely focused on the student experience, and research is steadily accumulating to support student-related outcomes. Much less is known about the professional engineers who volunteer their time to review the reports, including what they contribute to the framing of global responsibility and how their volunteer experience constitutes a learning exercise not dissimilar from the students.

GOAL
This study seeks to broaden the understanding of how globally responsible engineering is defined, promoted, and practiced in a programme such as the design challenge. Volunteer reviewers are regarded as relevant experts, and their feedback shapes those framings and the student experience. This study also seeks to connect those contributions to aspects of conventional engineering practice and investigate the way in which volunteer reviewing is a learning experience.

METHODOLOGY
This mixed methods study includes a qualitative data analysis of documents produced for and within the design challenge, select interviews, and a participatory ethnography. The document analysis centred on reviewer feedback on student designs, their applications and reflections directly to Engineers Without Borders UK. In this paper the reviewer experience is described through documentation of the reviewer process, recorded experiences of the reviewer's contribution to the design challenge, and through the author's first-hand account as an active participant.

ACTUAL OUTCOMES
This study produced an extensive catalogue of the different ways volunteer reviewers interpret the meaning and encourage the practice of global responsibility. Patterns showing the focus or omissions within the reviewer feedback are parallel to the differences between conventional engineering practice and the ideal of global responsibility that the design challenge seeks to promote. Finally, the design challenge emerges as an educational and practical exercise for the reviewers, strengthening their globally responsible engineering orientation and skills, just as it is intended for student participants.

CONCLUSIONS
In the Engineering for People Design Challenge, the nuances and imperatives of global responsibility are collaboratively constructed between Engineers Without Borders UK, university students, their faculty, and professional engineers. In this unique configuration, conventional practices and forward-looking ideals, for both globally responsible engineering and engineering education more generally, are negotiated in real time. This research can also be considered a preliminary case study for new ways to deliver life-long learning, given the potential outcomes for many professionals volunteering their time on a scalable educational initiative.

KEYWORDS
globally responsible engineering; design challenge; continued professional development.

Introduction

The expectations and demands on those practicing and studying engineering, individually and collectively, are facing a dramatic reimagination. Engineering underpins all the Sustainable Development Goals, sustainable societies and inclusive economies. It is also key to recovering sustainably, regeneratively and inclusively from the COVID-19 pandemic (UNESCO, 2021). Further, engineering outcomes can have significant societal and environmental impact, and engineers must act responsibly to incorporate more than technical aspects of engineering outcomes. A study by the Institution of Engineering and Technology found 93% of engineering companies with a sustainability strategy do not have the staff with the skills to fulfil them (IET, 2021). There is a clear need for engineering curricula to incorporate the skills required to mitigate global and local challenges, societal aspirations and needs, while not compromising the natural environment or resources for future generations. In doing so more complexity, multi and interdisciplinary approaches are required in engineering curricula. The conventionally siloed skills, educational upbringings, and broad outlooks of these societal leaders is being challenged, including with new goals and ideals for global responsibility in engineering. While the curriculum for university education has not rapidly evolved to match these changing expectations, initiatives in and out of the classroom are beginning to incorporate tools and programmes to reshape the future of engineering.

Project and problem-based learning have been demonstrated as effective methods for approaching social responsibility in engineering education, leading students to explore non-technical approaches and consider the needs of people in engineering projects (Rulifson et al., 2018). In project-based learning, students approach complex and real-world problems, often collaboratively, for an extended period of time, culminating in a final product, with teachers acting primarily in advisory roles (Helle et al., 2006). It specifically has grown into a permanent fixture in engineering education following its initial introductions to foster “adept communicators, good team members, and lifelong learners” (Dym et al., 2005, p. 109). Complexity within problem-based learning through theory and application has a positive impact on professional competencies and can bridge the gap between education and industry (Steinemann, 2003; Lamb, et al, 2010).

Context

The Engineering for People Design Challenge is an educational programme run in partnership between Engineers Without Borders South Africa and Engineers Without Borders UK, based on a concept originally developed by Engineers Without Borders Australia. The award winning challenge is delivered collaboratively with universities nationally in the UK, Ireland, South Africa and the USA and invites teams of students to practice using their skills and knowledge to create engineering design proposals to address ethical, environmental, social and cultural aspects of engineering design in complex development contexts (Engineers Without Borders UK, 2021). The design challenge has been consistently growing in scale since it was first launched in the UK in 2011. In 2019/20, 37 universities across the UK, Ireland, South Africa and the USA took part in the design challenge, and to date has reached over 50,000 undergraduates. In the UK, the programme contributes to requirements set out by the Engineering Council for accredited degrees, to demonstrate understanding of the design process and have a broad awareness of the economic, legal, social, ethical and environmental context of engineering.

Different design briefs are issued each year prompting students to tackle problems in different contexts, including in communities in India, Nepal, Cambodia, Australia, Vietnam, Timor Leste, Cameroon, Peru, and Kenya. The challenge explicitly focuses on 1) developing a broad set of skills, 2) designing for the people and context, 3) ensuring appropriateness and sustainability, 4) activating the relationship between the social, economic, and environmental implications of engineering decisions at local and global levels, and 5) broadening the conceptualizations of global responsibility in engineering. The programme is organized into two phases, with students first developing their proposals at their respective

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universities, and later competing against the top teams from across the region toward a grand finals event and celebration.

Volunteer professional engineers have a critical role as the reviewers during the competition phase of the challenge. The volunteer reviewers are pooled from the network of international and domestic professionals that Engineers Without Borders UK has built into its broader movement. Reviewer candidates submit an online application and once accepted are invited to a one-hour training webinar and provided with other fundamental resources for the challenge and their responsibilities. The student reports are paired with individual reviewers, whose evaluations then include both numerical scoring and qualitative feedback across the discrete marking criteria. Once the reviewers have submitted their evaluations, they are later invited to complete a feedback form and have the opportunity to passively follow the final stages of the competitions.

Reviewers' scoring determines which teams advance from the initial round of the competition phase to the Grand Finals, and their comments are the primary source of qualitative feedback that the students receive from outside of academia. The reviewers are at various stages of their careers, from a broad range of technical disciplines, and represent diverse perspectives from within the design challenge and across the broader engineering community as well. Furthermore, while reviewers are provided with standardized training and background materials, their focuses, orientations, and priorities primarily come from their own experience outside the challenge itself.

The contributions of the reviewers to the design challenge can build upon and represent a distinct perspective on globally responsible engineering and the criteria to which these types of designs can be evaluated. While the qualitative feedback from reviewers to the students is structured by the marking criteria and Engineers Without Borders UK's framing of global responsibility, it is produced freeform and delivered unredacted. Through their reviews of student reports, the reviewers interpret these concepts, bring in their own additions, and focus on the areas which are most central to their conceptions of engineering responsibility.

The applications and post-participation surveys moreover invite additional insights into their orientations, motivations, and visions. Together these contributions speak to the reviewers' perspectives on: their personal situation within contemporary engineering systems; the direct value of their contributions to the design challenge and its participants; and the underlying value, importance and influence of project-based learning initiatives such as the design challenge to engineering industries and society as a whole.

Research Questions

This paper presents the results from a nine-month study, conducted between January and September 2020, of the concepts of globally responsible engineering and the way that it is promoted and enacted through the Engineering for People Design Challenge. The research questions that this paper explores are as follows:

1. In what ways does participating as a reviewer in the design challenge go beyond industry practice and straightforward volunteering?
2. In what ways can it be considered itself a lesson and exercise of globally responsible engineering?

First, it looks at the way that various actors collaboratively create the definition of globally responsible engineering, with a particular focus on the reviewers' contribution to that definition. Second, the report takes a closer look at the reviewers, their contributions, and their experiences, including how the reviewers view and approach the design challenge, their role in it, and the globally responsible engineering concepts they are tasked with evaluating. Finally, it draws parallels and differences between professional engineering career experience, the volunteer reviewer experience, and the student participant experience.

Methodology

This study used decidedly mixed methods to conduct a qualitative data analysis of documents created for and within the design challenge. The main dataset was written contributions from the reviewers throughout their applications, reviews, and post-participation surveys. This analysis looked at 533 total reviews across three years of the challenge, from 2017-2019. Each review included feedback comments in each of six marking criteria plus a seventh for general comments. The data also included official materials and selected interviews with staff from Engineers Without Borders UK. QDA software Atlas.ti was used to code data to identify patterns, trends and themes. A portion of the research is also a participatory ethnography, as the first author made observations and reflections throughout the experiences of volunteering as a reviewer for the design challenge and working internally with Engineers Without Borders UK. These perspectives were unique and complementary, providing varying insights from administration to participation and from creation to contribution to delivery.

Results

While explicitly titled as an engineering design challenge and delivered exclusively to engineering students, neither calculations specifically nor technical outcomes related to engineering skills more generally are called out in the learning outcomes, submission guidelines, or marking criteria. Engineers Without Borders UK's intended learning outcomes emphasize targets related to globally responsible engineering, including designing for people and context, the social considerations in engineering decision making, and the central importance of engineering in guiding human development and protecting the planet. There is also a strong emphasis on other complementary professional skills that students develop, including in communication, project management, and teamwork. The guidelines presented to academics and students highlights the importance of working across disciplines and cultures, as well as finding a personal role in and connection to engineering. The version presented to the reviewers additionally notes that engineers in general need to learn to do all of these things better.

Report guidelines and marking criteria closely reflect these definitions and learning outcomes. The submission guidelines encourage a focus on and description of the processes of reaching their design and justification of its contextual appropriateness; consideration of its implementation and its many potential consequences; academic and professional presentation; and a reflection on their work as a team. The subset of comments that were analysed in detail are summarized in Table 1, categorized by the marking criteria they were pulled from and the global dimensions they were coded to.

Reviewing the global dimensions

The global dimensions outlined in Table 1 were recognised as interrelated. For example, environmental and economic considerations were notably mentioned when considering material sourcing and use. Material selection and component manufacturing were related to costs, embedded carbon, and place in product life cycle and supply and waste chains; availability of materials was related to local ecological conditions or local economic systems, production capabilities and affordability; and sourcing and material transportation was related to fuel use, emissions and costs. Reviewers recognize these relationships, and regularly describe and identify the synergies and links between the different global dimensions, regarding them as complementary. In addition, the dimensions are also viewed as mutually conflicting. The most common example from reviewers was how economic benefits often come at the expense of environmental harms, or vice versa. Similar trade-offs are referenced when social concerns negatively correlate with environmental or economic considerations. Reviewers further highlight conflicts between the environmental and community consultation

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dimensions, as communities with immediate challenges may not prioritize environmental protection or other sustainability concepts.

Table 1: Summary of comments coded to the global dimensions and in the marking criteria

Number of reviewer comments coded	Marking Criteria							Total
Global Dimension	1a – Environmental considerations	1b – Economic considerations	1c – Social community considerations	1d – Other global dimensions	2a – Implementation & appropriateness	2b – Methodical Assessment Process	[3] – General feedback	
Environmental context	**61**	3	2	14	1	1	17	99
Economic context	3	**95**	11	8	2	1	20	140
Social/ community context	2	11	**119**	11	12	2	36	193
Community consultation	7	10	67	**66**	38	5	66	259
Ethical responsibilities	11	14	14	**41**	9	3	51	143
Longevity	0	6	1	**22**	2	0	6	37
Total	84	139	214	162	64	12	196	871

Reviewers often focused on engineering analyses and other technical issues in their comments, despite no marking criteria covering this area. Other comments varied from emphasising the design challenge as an exercise in applying the global dimensions (rather than technical design), to praising technical rigor but encouraging a focus on the global dimensions for their own value and for the sake of good engineering. Notably, technical and social issues were recognised by reviewers as interdependent in engineering design. This relationship sometimes referred to the need to tailor technical features to social conditions, other times to designing technical features to address social conditions. The comments further emphasise that social conflict can result from unequal access to technical benefits or natural resources. Reviewers often comment that learning to navigate these conflicts is at the heart of the design challenge itself. At the same time, many of these same relationships and tensions come out in the reviewers' own contributions and perspectives.

Reviewer Reflections

Reviewer reflections on the marking criteria presented opposing views, with some enjoying navigating the complexity of the criteria, while others felt unprepared. Some reviewers advocated for more technically focussed review standards, including recommending its inclusion in the marking criteria. Noting the subjectivity of many categories, reviewers asked for simplifications, specifications, or elaborations in the training and guidance to help clarify the intended meaning of the criteria for global responsibility.

The reviewers also reflect on what they see as the benefits of participating in the design challenge. Responses range from framing the challenge as a rewarding service that they provide, helping a good cause and providing a path to influence the next generation, to considering it their responsibility to directly contribute to globally responsible engineering projects that help people, improve general welfare, and build a better world. While some of the reviewers describe this volunteer role as a natural extension of their everyday engineering work, most frame it as a fundamentally different type of experience that brought

them out of their comfort zones and a space to learn new things about technology, innovation, social justice, and the diversity of the world. Contributions as reviewers in the design challenge were also viewed as ways to help engineering be used as a tool for social mobility and environmental guardianship on broader scales.

Notably, responses included that the challenge reminded them of reasons why they became engineers and they feel inspired to bring those notions back to everyday practice, for themselves, their peers, and students they mentor. These responses suggest reviewers see their role in the design challenge as a path to help students, become a part of the same mission that the students are tackling and finally to help change engineering to be more oriented toward those goals.

Discussion

For the reviewers, the experience is educational and practical in many of the same ways as for the students. Reviewers are trained of engineering's relationship to a long list of factors, including the six global dimensions. Further, reviewers consistently integrate additional considerations including political power, health and safety, and equity and justice. Providing minimum services and quality of life to people around the world and the engineers role in building a more environmentally sustainable society are consistently advocated for. Including scaling proposals from short to the long term and from locally to globally.

While not part of the evaluation criteria, technical and quantitative analyses were strongly emphasised in reviewer feedback to the students and advocated for inclusion in the marking criteria. This extends to critiques on economic analysis and quality of writing and presentation. Reviewers' perspectives and comments were sometimes more aligned with technologies and methods they were familiar with in practice, or on aspects that may be relevant to the reviewers day-to-day but would be a small consideration in the student proposal (e.g., selection, sourcing, and transportation of materials). While the social implications of many engineering disciplines are clear, the day-to-day reality of the work likely remains highly technical. Whether deliberately or habitually, the reviewers are demonstrating and passing on this technical focus to the next generation of engineers through their feedback and focus.

This focus on technical feedback may be at the expense of the qualitative and contextual elements. Reviewers commonly referred to a global dimension by name in feedback with limited connection to the proposal or their views. This does not indicate a misunderstanding of the concept but does suggest reviewers may be less comfortable speaking to the global dimensions, particularly if everyday exposure and experience is limited in their professional work. Specific social issues that the reviewers explored often had already been introduced in the design brief or by students in their reports. For example: in 2017, reviewers spoke regularly of the effects of meteorological concerns, after the design brief singled out the El Niño weather pattern as a major social influence in Lobitos, Peru; in 2018, discussions of crime and vandalism were disproportionately common, after the design brief introduced them as fundamental concerns in Kibera, Kenya; and in 2019, the reviewers commonly explored sexual violence and social inequality, after the design brief introduced women's struggles and the caste system in Tamil Nadu, India. This pattern is largely attributed to students setting the stage to focus on these topics.

The reviewers often talk about change in ways that may be in parallel with industry practices and expectations. They routinely compliment and advocate for scalable solutions that can effectively have a multiplying impact with a single design, speak of tailoring solutions to specific problem contexts and to putting oneself in the shoes of users and clients. They also commonly remind students that technical aspects are only part of a project, that each project plays only a part in larger societal systems, and that each project and location is part of progressively larger scale, from local to global.

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In their short contributions to the design challenge, reviewers are expected to represent their technical disciplines as subject matter experts, study the design brief and familiarize themselves with a brand new context, evaluate student reports based on a specialized but broad set of criteria that define Globally Responsible Engineering, and be excellent communicators, educators, and mentors. The reviewer role is framed as a service opportunity for professionals to help lead the next generation of engineering students toward the principles of globally responsible engineering. However, it can also be plainly interpreted as an educational exercise in globally responsible engineering for professionals. The training, guidance and communication directed at the reviewers supports this aspect of the experience, as they are immersed in what globally responsible engineering is, why it is important, and how it can be practiced and promoted. The training webinar in particular is similar to the student launch lectures given at the beginning of the challenge. When the organizers annotate previous exemplary reviewer feedback, they additionally set examples and benchmarks for how to interpret the global dimensions and engage with students.

In many ways, the reviewers also see the experience in the same way as training and practice for globally responsible engineering. They actively engage with concepts of global responsibility in their reviews, sometimes with the tone of a teacher, but often with the mindset of a learner, exploring ideas collaboratively with the students and organizers. Many reflect on ways in which they felt uncertain or unprepared to act as experts in globally responsible engineering and ask for more help in reaching that level, such calibrating their scoring and feedback based on these benchmarks. This suggests reflecting on other reviews and reports is an exercise and demonstration of a desire to personally understand how the context and concepts are most effectively applied, what should be expected of the students, the reviewers own place in the larger schemes of the design challenge and the push toward industry-wide globally responsible engineering. When the reviewers note how different this volunteer role is compared to their everyday industry work, they are valuing the new experiences and the knowledge gained from them. They regret that globally responsible engineering principles are not more frequently exercised in professional practice and praise the design challenge as a beneficial space to revisit them. Finally, when the reviewers look to their peers to build a community, they are acting on the knowledge that they are not alone in experiencing the design challenge this way and seek to scale their impact through these channels.

The reviewers' contributions and experience broadly fit the description of 'service learning', where students "participate in an organized service activity that [addresses] community needs, and reflect ... to gain further understanding of course content, a broader appreciation of the discipline, and an enhanced sense of civic responsibility" (Bringle et al., 2004, p. 5). Similar to project and problem-based learning, service learning has been shown to support learning outcomes, civic engagement, interpersonal relations among college students, and orientation toward social responsibility (Levesque-Bristol et al., 2011), and achieves "higher cognitive levels in some skills and in attitudes and identity outcomes (i.e., social and moral development)" (Bielefeldt et al., 2010, p. 542). When project-based, problem-based, and service learning programmes integrate with the targets of globally responsible engineering, it can provide pedagogical, educational and experiential benefits (Riley & Bloomgarden, 2006). These results further align with the intention of the organizers and the contributions and reflections of the reviewers.

Professional engineers have a responsibility to take all necessary steps to maintain and enhance their competence through continuing professional development as life-long learners. Further, registered engineering professionals are "required to demonstrate a personal and professional commitment to society, to the environment and to their profession" (Engineering Council, 2020, p. 9). Interpreting the reviewer role in the design challenge as a combination of continued professional development through project-based service learning experiences shines a new light on the individual experience, its power as a tool for personal

and professional growth, and the broad and multifaceted value of the design challenge as a development tool and scalable model for the entire industry.

This research primarily focussed on the reviewer process and contribution to the design challenge. In doing so the participation phase by university students of the design challenge is omitted. During this stage, there are potential parallels to explore between the academics' experience and those of the reviewers contributing to the design challenge, as they are guided by the framing of globally responsible engineering defined at the outset. As the delivery of the design challenge continues to expand internationally, further work could explore how the perspectives and understanding of globally responsible engineering from students, academics and reviewers vary between geographical and cultural contexts.

Conclusion

This research set out to study varying aspects of responsibility in engineering in the context of an undergraduate engineering design competition. These aspects included how that responsibility is defined and described, how it is presumed to be enacted, and how those orientations are practiced and passed on to others. The reviewer experience often does not correlate closely to those in everyday engineering practice, and the experience as a whole does not so closely resemble typical professional volunteer work. Instead, the reviewer experience has much more in common with that of the students, and is similarly a legitimate, valuable, and constructive educational itself in globally responsible engineering.

Problem based learning, such as the design challenge, is a unique and powerful tool for connecting across disciplines, experience levels, and communities, with the goal of redefining engineering and the way that it is taught and practiced. It is a collaboration between activists, industry professionals, students, and academics not just in stepping through the phases of the programme, but also for actively defining the ideals and goals that frame those steps and the desired outcomes.

The reviewer's participation in the design challenge can be viewed as a concurrent and specific learning experience that should be further explored in engineering education and continued professional development. Benefitting both the reviewers' own appreciation and application of globally responsible engineering and how they translate and promote it to student participants. These processes come together to build and form bonds between participating groups, combine their social and technical visions, and provide opportunities to enact and scale the impacts in engineering education and industry.

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