Development of Global Competencies through Humanitarian Engineering Experiences

Andrea Goncher, Joshua Devitt
Charles Sturt University, Faculty of Business, Justice, and Behavioural Sciences, CSU Engineering
Corresponding Author Email:agoncher@csu.edu.au

SESSION S3: Integrating Humanitarianism in Engineering Education

CONTEXT Engineering graduates need to be prepared and empowered to undertake sustainability challenges and other global issues (Brown, Price, Turner, & Colley, 2016). Understanding the socio-environmental impacts of engineering design are critical to sustainable engineering practice. Engineers, especially engineering students, can have the tendency to rush into defining solutions early in the design process without considering the ethical and sustainability issues in design and decision-making processes. EWB Australia has developed student programs, i.e. EWB Annual Challenge and EWB Design Summit, that are designed to embed people-centred approaches into engineering, and help to prepare graduates for a world where they will face increasingly complex sustainability issues)

PURPOSE This study examines how students' perspectives on humanitarian engineering and global sustainability competencies develop based on their humanitarian engineering experiences.

APPROACH Students participated in the EWB Australia Annual Challenge in their first year of university study, and EWB Australia Design Summit in the second year of the engineering course. We interviewed students before and after their humanitarian engineering experiences, based on the EWB Design Summit in Cambodia. Pre- and post- student interviews on the EWB Australia Design Summit experience were conducted and analysed.

RESULTS Participants found that their immersion in the community and engaging with the community members resulted in a more empathetic approach to design, that they were able to communicate in more challenging environments, and that they gained a global perspective on the impacts of engineering design.

CONCLUSIONS Exposure and participation in humanitarian engineering experiences, like the EWB Australia programs, help students to realise that engineers operate in a holistic society and consider social factors that affect design. Facilitating students in these experiences will help to develop global competencies, by considering the social, environmental, and economic impacts of their designs, and improve their capacity to be a more well-rounded and global engineer.

KEYWORDS humanitarian engineering; design thinking; human-centred design;

Introduction

Engineering graduates need to be prepared and empowered to undertake sustainability challenges and other global issues (Brown, Price, Turner, & Colley, 2016). Understanding the socio-environmental impacts of engineering design are critical to sustainable engineering practice. Engineers, especially engineering students, can have the tendency to rush into defining solutions early in the design process without considering the ethical and sustainability issues in design and decision-making processes (Goncher & Johri, 2015). This paper focuses on the experiences of engineering students who participated a humanitarian engineering program, and the impact on students' perspectives of global issues in engineering. Reflections and insights from these experiences will be mapped to global competencies examines how students' perspectives on humanitarian engineering and global sustainability competencies develop based on their humanitarian engineering experiences.

Design Thinking in Humanitarian Engineering

Human-centred design (HCD), requires practitioners to empathise with end-users and identify the needs of those users rather than starting with solutions for the end-user. HCD has been identified as an effective approach to address poverty and development issues around the world (Kramer, Poreh, Agogino, 2017). Design thinking (Brown, 2008) provides framework for designers to perform needs assessment and encourages iterative design. Levine, Agogino, and Lesniewski (2016) suggest that design thinking is foundation to development engineering, and framed development engineering from a design thinking perspective to include development goals and constraints as well as business models for scaling (Levine et al., 2016). Figure 1 illustrates Levine et al.'s framework that applies elements in an iterative and overarching method, while incorporating on the various phases of HCD, e.g. ideation and prototyping.

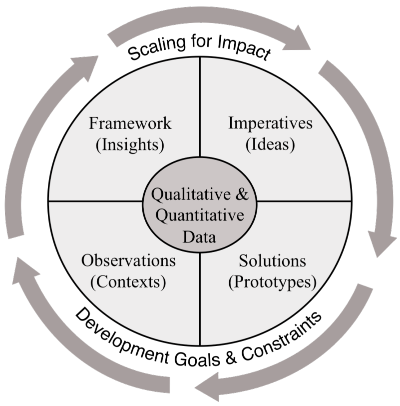

Figure 1: Design Thinking Framework (reproduced from Levine, Agogino, Lesniewski, 2016)

The human-centred design approach incorporates design thinking. HCD utilises the needs assessment in the discovery and emphasise phases, and encourages rapid prototyping (Brown, 2008) and communication with the end-users. We utilise the Design Thinking for Development Engineering (Levine et al., 2016) to this study's focus on humanitarian engineering experiences. The design phases related to insights, ideas, contexts, and prototypes and their relationship to development goals and constraints and scaling for impact will be important to highlight how design thinking in humanitarian engineering can be used to analyse students' experiences.

The context of this study is a humanitarian engineering experience that incorporates the human-centred design approach to expose students to ethical, sustainability, and development issues in engineering. The follow section provides a description of the experience, and the role of students and academics in the summit.

Engineers Without Borders Design Summit

Engineers Without Borders Australia (EWB) has developed a number of programs that are designed to develop human centred design skills in students. These include the EWB challenge and the EWB humanitarian design summit program. Both programs require students to actively engage with the human centred design (HCD) process. The learning outcomes of these programs also help students develop global competencies relating to humanitarian design, as outlined in Klein-Gardner and Walker (2011).

The EWB challenge is a first-year engineering design subject offered in most universities across Australia and New Zealand. Students undertake a semester long, team-based, design project to address a design brief. This "design brief is based on a set of sustainable development projects identified by EWB with its community-based partner organisations" (EWB, 2017a). This provides students with an opportunity to engage with the HCD in a theoretical context, to begin to understand the process and to develop their understanding of humanitarian centred design. [University] offers this program as a required course for all first-year student engineers as a project based learning subject. Unique to [university], each team of student engineers is assigned an academic mentor who works exclusively with that team. Student engineers are encouraged to develop their own understanding of the design areas through research and exploring [university's] curriculum, enabling a deeper understanding of the subject matter in a context reflective of industry practice.

The EWB humanitarian design summit program provides an opportunity for engineering students to experience humanitarian engineering in a realistic context. The program consists of an intensive two weeks overseas, working with EWB community partners to understand their culture, context and development related challenges. Students are required to actively engage with the HCD process and ultimately identify opportunities for these communities to address their development goals. The programs operated with a strength's based approach and focus on developing long term partnerships between EWB and local community organisations in-country. Students are accompanied by facilitators from both industry and academic backgrounds, "who guide the participant learning experience and ensure the safety and wellbeing of the group" (EWB, 2017b).

Eight students were accepted to attend the EWB humanitarian design summit to Cambodia in June and July 2017. These students represented a variety of gender, age and cultural backgrounds. All were either first year or second year students of [university's] Engineering's bachelor of civil engineering program. Each of these students had already completed the EWB challenge as a part of their first-year studies. Two academic staff members were also selected to accompany the student engineers on the design summit as academic fellows. The role of the academic fellows being to "facilitate the learning and educational experience of student participants" (EWB, 2017b). Prior to embarking on the design summit each of the student engineers completed a series of questions on their understanding of development and humanitarian engineering.

The summit commenced in Phnom Penh with the first four days spent developing an understanding of Cambodian culture through a range of exercises including a series of pre-placement workshops run by the facilitation team. These workshops introduced participants to the HCD process as well as some key considerations of humanitarian engineering, sustainability, and the strengths based approach to development. Students also had a chance to apply what they had learnt through a series of exercises, engaging with the local community. One of the key considerations that was stressed at this stage was the need to focus on understanding the context and culture of Cambodia before starting to define solutions, a tendency that engineering students are known to exhibit (Goncher & Johri, 2015).

The middle stage of the design summit consisted of a home-stay experience in a rural Cambodian village. This provided an opportunity to experience the realities of life in a developing rural community. Students undertook activities designed to develop cultural understanding of the realities of life for these people. Activities including participating in agricultural practices, food preparation and cultural events. Students also observed examples of community events, cultural practices, educational practices, employment opportunities, health and hygiene practices, food preparation and waste disposal. They conducted interviews with members of the village using translators to develop a deeper understanding of what they were observing. These activities were designed to provide a wealth of learning opportunities as well as a practical application of the 'discover' and 'empathise' phases of the HCD process. Students were encouraged to reflect daily on what they observed in the communities and to link their reflections to their evolving understanding of development and humanitarian engineering.

The remainder of the design summit was spent taking the knowledge gained during the community visits to develop potential solutions for the community. Students formed into teams, collating the information gained during the 'discover' and 'empathise' phases, which they then fed into the 'ideate' and 'prototype' phases of the HCD process. Final design solutions were developed and presented to representatives from each of the communities that were visited during the summit, these representatives provided feedback on the practicalities and potential for implementation of the design solutions produced by the student teams. This process provided students with an opportunity to complete the HCD process and develop an understanding that the best design intentions may not always be appropriate for their intended stakeholders.

Upon returning from the design summit each of the students were asked to reflect on how their understanding of development and humanitarian engineering had changed because of their experience.

Both the EWB design challenge and the EWB humanitarian design summit programs provide a wealth of opportunities for students to develop their knowledge of humanitarian engineering and to implement the HCD across a range of contexts. As such these programs address the [students] graduate learning outcomes of 'global citizenship' and 'sustainable practice' as well as the Engineers Australia (EA) stage 1 competency 1.6 c: 'appreciate the social environmental, and economic principles of sustainable practice'. Students also have the opportunity to develop their understanding of HCD in the context of some of the sustainable development goals, namely: 'clean water and sanitation', 'affordable, clean energy', 'industry, innovation and infrastructure' as well as 'sustainable cities and communities'.

Methods

This study examined how students' perspectives on humanitarian engineering and global sustainability competencies develop based on their humanitarian engineering experiences. Participants in this study included six males, two females; of the six participants, two participants had cultural backgrounds from a South East Asian background. These two participants were born in South East Asia before moving to and living in Australia, and experienced similar living experiences to the immersive cultural experiences as part of the Design Summit. Design Summit participants in this study received course credit for their participation and completion of assessment tasks, however the participation was not a requirement of the course completion, or requirements. All participants that responded to the interviews and were part of the summit as part of the Engineering course, are included as participants in this study.

We collected student-produced documents, such as reflections, related to the EWB Design Summit. Pre- and post- student interviews and reflections from the EWB Australia design summit was analysed based on the coding structure in Table 1. Students' perspectives on their experiences of global competencies, as they relate to humanitarian engineering and development,

The researchers analysed eight student participant's pre- and post- summit responses. Students answered the question prior to the beginning of the design summit, and then immediately after the community stay and conclusion of the summit.

Table 1: Humanitarian Engineering Experiences Coding Structure

Code	Sub-code	Definition
Human Centred Design		Design thinking/ understanding the problem, context, needs, and prototyping solutions
Humanitarian Engineering		Reference to humanitarian engineering, or humanitarian engineering contexts
	Development, Disability	Humanitarian Engineering encompassing more than technology or disaster relief (Smith, Compston, Male, Baillie, & Turner, 2016)
	Social, Cultural, and Environmental	Relevance of social, cultural, and environmental context to engineering (Smith, Compston, Male, Baillie, & Turner, 2016)

The coding structure was based on previous literature regarding design thinking in development engineering (Levine, Agogino, & Lesniewski, 2016) and relevant engineering education work in humanitarian engineering (Smith, Compston, Male, Baillie, & Turner, 2016).

Results

The pre-summit and post-summit interview questions prompted students to define engineering and humanitarian engineering. The purpose of the study was to examine if the summit experiences contributed to students' development in engineering competencies. The analysis identified students' perspectives on engineering prior to, and after the design summit experience.

We found that prior to the summit 50 percent of the participants' definition of engineering included reference to an engineer's/ engineering's role in society, e.g. Participant 1: *"Engineering to me is basically putting together skills you've learnt from technology and maths and trying to incorporate that into addressing a problem that's beneficial to society."* Twenty-five percent of participants did not refer to engineering from a societal or people/ community-impacted, e.g. Participant 4: *"engineering is a profession that deals with problem solving by individuals with specialised knowledge and skills for problems of high complexity and requires a very high level of understanding."* The other 25 percent indicated a change in the participants' initial definition from a professional-oriented job to include the role of engineering in society, e.g. Participant 5: *"Initially thinking it being more of a profession, and now considering it more of a mindset and more of an approach to complex solutions, as well as simple solutions. But more in the aspects of technical problems which are experienced by those in the community that may not have specific knowledge of what the solution might be or how to approach that solution*."

Sustainable decision-making processes that consider appropriate sustainability and ethical issues are key to developing appropriate technologies and designs that create positive change in developing communities. Students viewed the role of humanitarian engineers to include empathising with the communities, and did not include disaster relief based on their post-summit responses. Below is an example of a participant response that highlights the relevance of the social and cultural contexts.

"HE's have a responsibility to ensure their impact is that of a positive nature, that includes paying attention to what a community needs as opposed to what may be considered as a requirement by an outside individual or entity. HE's must be very sensitive and respectful to cultural traditions by enriching themselves with cultural knowledge before attempting to empathise with communities and explore design opportunities. An emphasis is to be placed on empathy, one of the essential tools required for a humanitarian engineer."

Students who worked with the community partners in during the Design Summit Program in Cambodia utilized the context of the community when defining the design opportunity and were more sensitive to the end-user requirements. Experiences, such as working with the community members in the corn fields or interviewing the school teacher, clarified the importance of end-user requirements. The Summit's pre-community activities introduced students to the phases of the HCD. For example, the empathise phase activity facilitated students to interact with people that could be user of a proposed design idea.

As part of the EWB Design Summit, students engaged in activities, that encouraged them to think about empathising with the end user, an example of students designing improvements for Tuk Tuk drivers' transportation solutions is seen in Figure 1. Other program graduates reflected that the Design Summit allowed them communicate in more challenging situations, and that they gained a more global perspective on the impacts of engineering design.

Figure 2: Empathise Design Phase Activity

Design Summit engineering student participants reported that their immersion in the community and engaging with the community members, resulted in a more empathetic approach to design where they defined the design opportunity from the user's perspective rather than their own perspectives.

The post-summit responses analysed participants' perspectives on engineering and development to reflect any perspective changes in the engineering global competencies. The flowing quote from Participant 4 highlights a development in this students' perspective of their ability to understand the implications of cultural differences and an appreciation of other cultures (Klein-Gardner, and Walker, 2011).

Participant 4: "My definition of development has shifted somewhat, but I believed that if people had access to running water and sanitation, electricity, education and health services, then they would be considered developed. This idea has changed a little though and broadened. While these are all still good indicators, they don't represent true development. Given the Cambodian context, there were elements of these

> indicators which did exist in all the communities that I saw, from the city, small towns, and even in the tiny village communities. For me, having observed the presence of many of these key indicators and noting the absence of others, it became apparent that these alone did not signify development, especially in instances where there were obvious external inputs. My definition of development is one where these facilities and services still exist, but they are instigated and installed, developed and improved by the local people and not by an outside source. And to this end, if the local community can facilitate their own improvement, then they are developing.

The post-summit responses of participants' perspectives on engineering and development focused on how the experience of the summit incorporated participants' reflection of HCD, Sustainability, and how the experiences allowed students to communicate across cultures and deal with ethical issues. The EWB- supported experiences, in conjunction with the project-based learning approach, provide a scaffolded opportunity for students to experience realistic humanitarian engineering design experiences that contribute to the development of graduate global competencies.

Discussion

Several of the student engineers who attended the design summit have cultural backgrounds that are of a similar context to that experienced in Cambodia. This may have helped them to develop a deeper understanding of the culture and context that they experienced on the design summit as opposed to those students with a more western based cultural background.

One of the key points that was stressed continuously throughout the design summit by the facilitation team was that the aim of the summit was not to apply practical engineering skills but to develop a deeper understanding of another culture and their development related opportunities. In general, the students were mindful of this approach, engaging with the community visits by trying to understand rather than seek solutions.

Through attending the design summit closely after completion of the EWB design challenge, the students were well prepared to actively engage with the HCD process.

Limitations to the study presented in this article are a small subset of participants, compared to students that participated in both the EWB challenge, Design Summit, and are included in the CSU Engineering course curriculum. As part of the qualitative research analysis structure, we aim to provide representative sample, focusing on a particular context in more detail. We also acknowledge the limitations of the context of the study that provides an immersive experience for students within a specific engineering development context.

Recommendations for the engineering education community that are interested in implementing results from the participants, would be to develop design activities that incorporate societal factors into engineering design earlier in the curriculum. Incorporating societal factors into engineering design (Smith, Compston, Male, Baillie, & Turner, 2016) are important to developing students' global competencies. Students who are exposed to HCD and other sustainable design practices should benefit from additional experiences that expose students to various factors, e.g. societal, environmental and cultural, impacting engineering design. The immersive experiences helped students to be sensitive to end-use requirements, gain global perspective on impacts of engineering design, and communicate in more challenging environments, are impactful to developing global competencies. Recommendations for contexts that are not able to provide immersive experiences would be to provide activities that allow, and encourage, students to consider the social factors that impact design and how students should incorporate other environmental and cultural factors into engineering design.

Conclusion

Engineers operate in a holistic society, where a concern for the environment and the user is key to engineering design. Facilitating students to use a human-centred design approach, by considering the social, environmental, and economic impacts of their designs, improves their competency to be a more well-rounded and global engineer. Experiences, such as the Design Summit, where students are exposed to opportunities that can allow them to utilise or apply global competencies as humanitarian engineers is beneficial toward their overall professional identity as an engineer.

References

Brown, N. J., Price, J., Turner, J. P., & Colley, A. (2016). Professional development within study abroad programs for engineering educators to gain confidence in preparing students to contribute to the Sustainable Development Goals. In *27th Annual Conference of the Australasian Association for Engineering Education: AAEE 2016* (p. 96). Southern Cross University.

Engineers Without Borders Australia. (2017a). The EWB Challenge. Retrieved from http://www.ewbchallenge.org/content/about-program

Engineers Without Borders Australia. (2017b). Position Description – Design Summit Academic Fellow.

Goncher, A., & Johri, A. (2015). Contextual Constraining of Student Design Practices. Journal of Engineering Education, 104: 252-278. doi: 10.1002/jee.20079

Klein-Gardner, S. S., & Walker, A. (2011). Defining global competence for engineering students. In American Society for Engineering Education. American Society for Engineering Education.

Kramer, J., Poreh, D., & Agogino, A. (2017). Using TheDesignExchange as a knowledge platform for human-centered design-driven global development. In DS 87-1 Proceedings of the 21st International Conference on Engineering Design (ICED 17) Vol 1: Resource Sensitive Design, Design Research Applications and Case Studies, Vancouver, Canada, 21-25.08. 2017.

Levine, D. I., Lesniewski, M. A., & Agogino, A. M. (2016). Design Thinking in Development Engineering. INTERNATIONAL JOURNAL OF ENGINEERING EDUCATION, 32(3), 1396-1406.

Levine, D. I., Agogino, A. M., and Lesniewski, M. A. (2015), “Design Thinking in Development Engineering”. Proceedings of the 2015 Harvey Mudd Design Workshop IX.

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