



Emergence and evolution of Humanitarian Engineering Education in Australia

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Evolution of Humanitarian Engineering in Australia

Introduction

The role of engineering within short- and long-term humanitarian action and human development activities is well established. In such practice, engineers can be undertaking post-natural disaster assessments of infrastructure, establishing emergency relief camps including temporary shelter, energy and water, developing appropriate technologies, and providing sustainable and reliable access to improved health, economic opportunity and security [1]–[3]. Such efforts currently align with internationally recognised frameworks including the Sphere Handbook, Charter and Standards, for short-term humanitarian response [4], the Sendai Framework, for disaster preparedness [5], and the United Nations (UN) Sustainable Development Goals (SDGs), focusing on long-term development [6].

This dedicated role for engineering began to be documented in the 1970's, through work such as *Small is Beautiful* [7], which captured concepts such as appropriate technology, and the 1980's, through the work and books of Fred Cuny, which focused on disaster response[8]–[11]. At this time, the first dedicated organisations focused on engineering and technology in humanitarian response and development emerged. RedR UK was established in 1980 with an initial focus on maintaining a register of qualified and experienced engineers for disaster response [12] while in 1982, the first Ingénieurs Sans Frontières (Engineers Without Borders, EWB) was established in France [13]. The 1980's and 1990's saw increased development of specialist capability through further national organisations in Europe and North America. In the 1990's, the first dedicated university programs emerged, predominately in the United States (US). The turn of the 20th Century saw continued growth across North America, Europe and Oceania, first aligning the UN Millennium Development Goals (MDGs) and now the SDGs and other governing international frameworks [14]. Many countries now have multiple organisations and education programs in the area.

This paper outlines the rise of this area in Australia, where at the time of writing, such engineering practice and education is referred to as Humanitarian Engineering (HumEng). The paper outlines the initiative emergence and gradual establishment in the 1990's and 2000's, and rapid increase from around 2015, with universities and engineering education programs central to this rise. A summary of the current state of the field is provided, outlining challenges and opportunities for the field as a whole of this recent growth using the Australian case as an example to reflect on the growth of the area and its current status. This is in order to encourage further discussion nationally and internationally, to further expand the capability and capacity of the engineering profession to respond to increasingly complex, large, and more frequent humanitarian and human development challenges and responses in the 21st century.

Humanitarian Engineering in Australia

Emergence

The first organisation in Australia to bring specialist engineering expertise to bear on humanitarian and development challenges was RedR Australia, founded in 1992. Working under the same model as RedR-UK, it maintained a register of experienced engineers who could be called upon to be deployed at short-notice for international (non-Australian) disaster response. In 2003, Engineers Without Borders Australia (EWB-A) was established as an independent national organisation. EWB-A's focus was on long-term community development both in Australia and overseas. When first established, this had a mission of working "with disadvantaged communities to improve their quality of life through education and the implementation of sustainable engineering programs," in order to achieve sustainable development [15]. Before 2010, both RedR Australia and EWB-A provided expertise to local organisations through placements and provided education and training programs in Australia.

In 2011, the peak professional body for engineering in Australia, Engineers Australia (EA) declared 2011 to be the "Year of Humanitarian Engineering", following on from a number of other profile "Years of". This helped to increase awareness of the area in Australia, highlighting the work of both EWB-A and RedR Australia. It also led to expanded use of the specific term "Humanitarian Engineering", which had otherwise not been in wide-spread use. For example, that term was not present in any EWB-A material or reports prior to 2011.

Establishment and Growth

A key focus for EWB-A was to establish a range of education programs and work closely with universities to deliver them. Since 2007, the following three programs have been established by EWB-A, and individual programs established by universities:

EWB-A Challenge

An annual partnership between EWB-A, universities and community-based partner organisations. The Challenge allows engineering students to work in teams to create appropriate solutions to real-world challenges identified by partner organisations. Each year, EWB-A works with one community partner, ensuring all students have access to the same information and scope. It introduces students to engineering in a humanitarian or development context and provides the opportunity for creative problem solving. The Challenge targets first-year curriculum, often within an introduction to engineering unit, with universities adapting the program to meet course requirements. A team from each university is then invited to present their idea at an annual convention. The program launched nationally in 2007 with 21 partner universities, reaching approximately 3,500 students. In 2019, 9,930 university students were engaged across 26 universities in Australia and New Zealand. This represents between 60-80% of all incoming first year engineering students in accredited engineering programs across the two

countries. Figure 1 below shows the growth in student participants and university partners with the Challenge from 2007 to 2019.

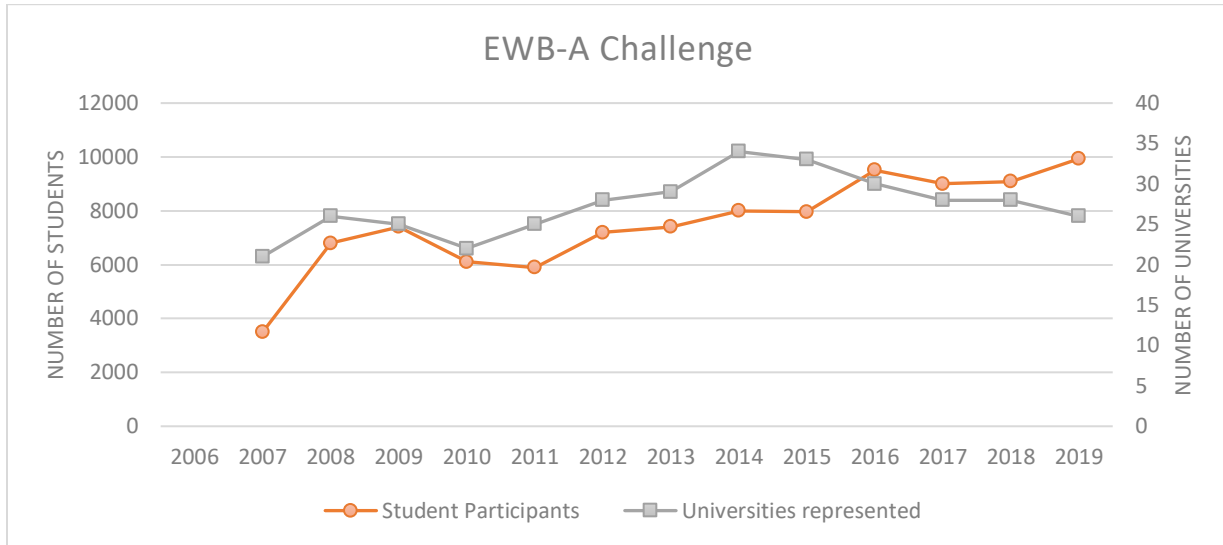


Figure 1 Engagement with the EWB-A challenge from 2006 to 2019. Data taken from [16]–[21]

EWB-A Humanitarian Design Summits

Launched in 2015, the Humanitarian Design Summits are two-week study-abroad experiences for university students studying engineering or a related field. Since commencing, over 1600 students have participated in 43 trips to locations including Nepal, Cambodia, Fiji, Samoa, India and Timor Leste. The Summits provide opportunities for students to deepen their understanding of Humanitarian Engineering, application of appropriate technology, working with communities to conduct needs analysis and develop problem definitions, Human Centered Design (HCD), rapid prototyping and hone their cross-cultural skills and client engagement. Figure 2 below shows the growth in student participation and resulting number of trips since they began.

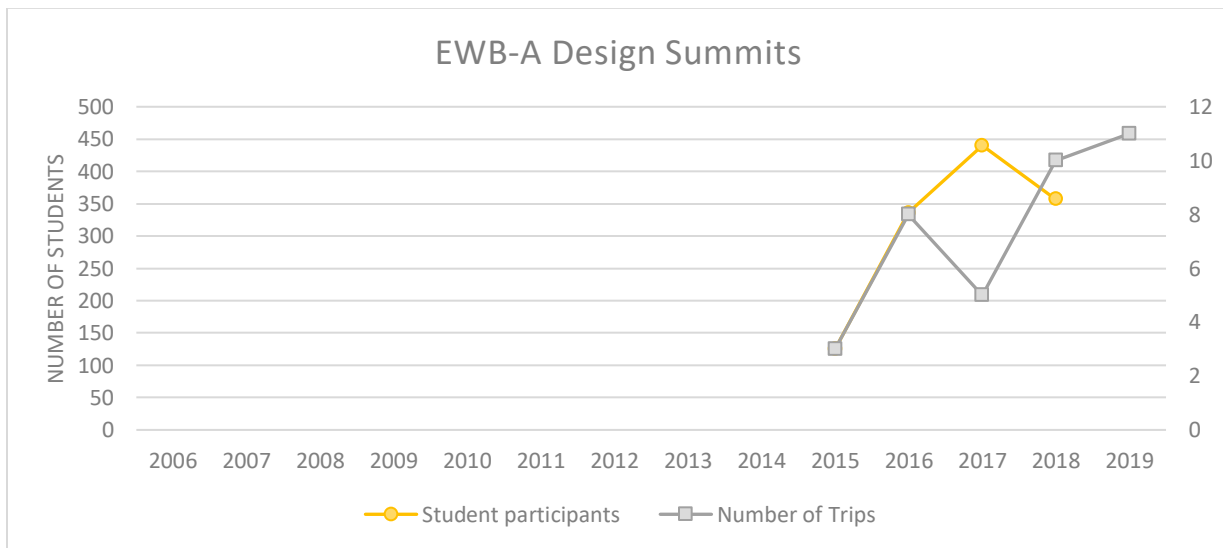


Figure 2 Student participation in summits since 2015. 2019 student data not available at this time. Data taken from [16]–[21]

EWB-A Research Program

Designed for final year-students completing individual or group research projects, the EWB-A Research Program is a service-learning style program that works with partner organisations and students on a specific topic. This provides students the opportunity to apply their university skills and knowledge alongside community engagement to work in the HumEng sector. These projects usually fit within a final year capstone or honours research project, with each of the partner universities working with EWB-A to incorporate projects into the curriculum. Since its inception in 2007, over 180 projects have been completed by 300 students. Figure 3 below shows the growth of the program, where data from 2010-2015 was unavailable.

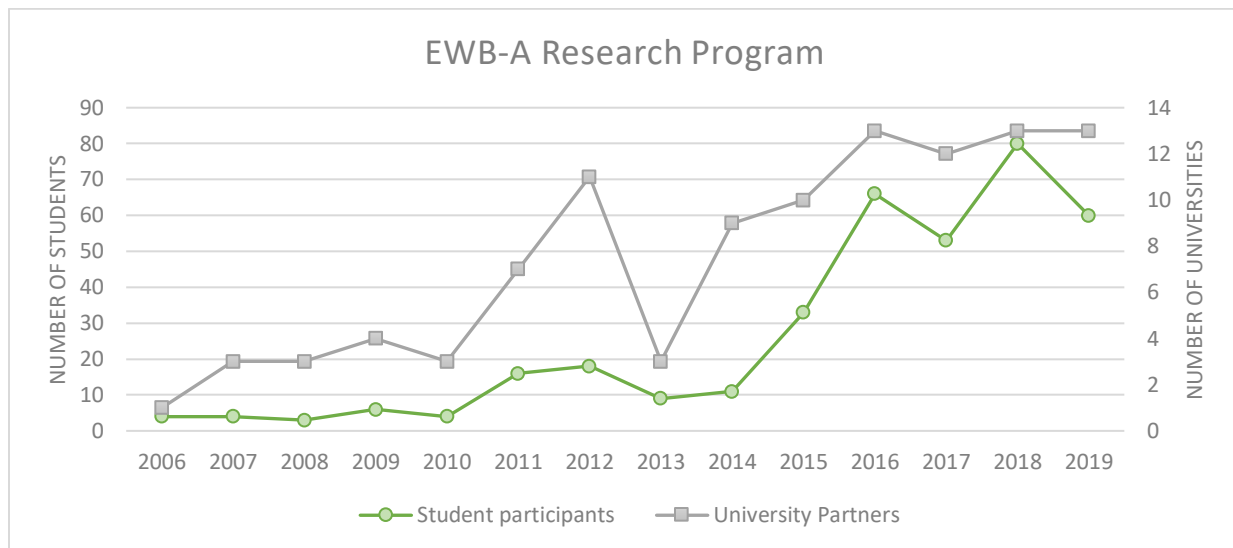


Figure 3 Student numbers and number of universities involved in the EWB-A research program. Data taken from [16]–[22]

University Courses

The growing student interest in HumEng through EWB-A opportunities prompted the development of university subjects, majors and minors. Currently, 11 institutions in Australia and New Zealand offer courses in Humanitarian Engineering and related subjects, ranging from groups of subjects in a major to individual courses and experiential opportunities [23]. The first Humanitarian Engineering course in Australia was developed in 2015 at the Australian National University, run in conjunction with an EWB-A Design Summit experience [24]. The *Engineering for a Humanitarian Context* course deepened students' understanding of development, HumEng principles and appropriate technology which then supported the Summit experience. After the Summit, students reflected on their experience from multiple stakeholder points of view and created a unique assignment from their experiences. Similar courses have been developed at multiple institutions since. These include Swinburne University's *Engineering Innovation in a Complex Environment* [25], Royal Melbourne Institute of Technology's (RMIT) *Humanitarian Experiential Learning Project* [26], University of Melbourne's *Humanitarian Design Internship* [27], and the University of Sydney's *Global Engineering Field Work* [28].

The growing interest in Humanitarian Engineering learning opportunities has created increasing demand for academic positions to increase offerings in the area. Since 2015, new positions have been established and advertised as *Humanitarian Engineering* academics, working to cultivate HumEng expertise and excellence at their institution. The twofold increase across 2018-2019 may be a reflection of the momentum from 2017 in the education community, as discussed below. Table 1 shows when universities offered new individual academic positions, with only one position advertised prior to 2017.

Table 1 Humanitarian Engineering university appointments. Note: these do not include existing staff who have transitioned into roles with a Humanitarian Engineering focus, only newly created positions.

University	Year (applications closed)
University of Sydney	2015
University of Sydney	2017
University of New South Wales	Feb 2018
RMIT University	Jan 2018
RMIT University	June 2019
University of Technology Sydney	Feb 2020

Academic appointments also reflect a growing body of literature, peaking in 2017. Within the academy, citations including the term ‘*humanitarian engineering*’ have increased. In particular, the annual Australasian Association for Engineering Education (AAEE) Conference has helped to promote this term. Since 2015, 12 papers have used the term ‘humanitarian engineering’ in the title or abstract, with the highest frequency in 2017. This is to be expected, as a dedicated session was held for HumEng at the 2017 conference. In recent years, the terms ‘socio-technical thinking’ and ‘human centered design’ have been increasingly used, shifting away from only using the term ‘humanitarian engineering’

Table 2 below compares the number of publications that include the term ‘humanitarian engineering’ across AAEE, the Australian Journal of Engineering Education (AJEE), the Journal of Engineering Education (JEE) and the American Society for Engineering Education (ASEE). In comparison, conference papers from ASEE have greater consistency of using the term than AAEE but the number of articles are comparable, excluding 2017, as ASEE has approximately 12 fold the number of total papers each year when compared to AAEE. ASEE has been generating HumEng educational research for longer than AAEE or AJEE, with the first HumEng papers emerging in 2003. This is not unexpected, as the field emerged later in Australia than the US. Overall, HumEng publications in JEE prior to 2018 are similar in number to AJEE after 2018, perhaps indicating JEE academics are transitioning to new terms sooner than Australasia.

Table 2 Number of publications from AAEE, AJEE, JEE and ASEE using the term 'Humanitarian Engineering'

Year	AAEE papers	AJEE articles	JEE articles	ASEE papers
2015	3	0	1	17
2016	1	0	0	13
2017	6	0	1	17
2018	2	1	0	10
2019	Not available	1	0	16

Recognition and Professionalisation

With the rapid increase in programs from providers such as EWB-A, Unbound and Pollinate, the increase in university offerings and academic positions, sector-wide engagement and recognition for HumEng in Australia emerged in 2017. In mid-2017 the Humanitarian Engineering Education Network of Australasia (HEENA) was established as an informal network for educators in the area to share ideas, opportunities and collaborations. This network sponsored a dedicated special session (one of four) on the area as part of the annual AAEE conference in December 2017 (see Table 2 above for numbers of papers). This was followed in early 2018 with the publication of a position statement by the national Australian Council of Engineering Deans (ACED) for *Humanitarian Engineering Education*, the fourth such position paper it had published at the time. This outlined opportunities and challenges for continued growth in the area, and was supported by HEENA.

In 2019, the EA College of Leadership and Management (CLM), the only non-discipline specific College of EA, proposed a dedicated Community of Practice (CoP) for Humanitarian Engineering. This was endorsed by the national CLM Board and established in the final quarter of 2019, hosted within the platforms and frameworks of EA. Around the same time, EA and EWB-A finalised an arrangement that EWB-A field volunteers would be recognised with 12 of the 16 competencies of a Stage 2 Chartered Engineering within EA's framework, where Stage 2 accreditation is equivalent to a licensed Professional Engineer in the United States.

As part of a major review in 2019/2020 of The Australian and New Zealand Standard Research Classification (ANZSRC), which govern research reporting and metrics in Australia, a new Field of Research (FoR) has been proposed for *Humanitarian Engineering*. This would allow research investments and activities in the area to be directly reported on and measured for universities and any organisation involved in research.

Discussion

The swelling support, interest and recognition of HumEng in Australia has sparked student interest, academic literature and investment from institutions in the area. EWB-A was an initial driver of this, building momentum through education programs and partnerships with universities. New academic appointments and a growing number of experiential providers indicate this growth is continuing.

EWB-A acting as a central hub, a collegiate spirit, government mobility grant funding and broader curriculum review and renewal were key enablers in the rise of Humanitarian Engineering in Australia.

EWB-A as a Hub

EWB-A has acted as a hub for the progression of Humanitarian Engineering, being a central body of knowledge, leader and core to the development of HumEng initiatives and collaborations in the field. As a central body, they were able to work closely with multiple universities, creating a network of academics and organisations to collaborate with. Many key members of EWB-A have moved to other organisations and continued to collaborate, creating a network for HumEng in Australasia and beyond. These collaborations have generated new initiatives, student experiences and opportunities to grow HumEng.

A core tenant of EWB-A is sustainable partnership building and radical collaboration. Consequently, these principles are core of HumEng education in Australia, enabling strategic and sustainable collaborations and partnerships, ventures and initiatives. This attitude of opportunity-seeking and openness allowed an equal space for any organisation, individual or university to contribute. In the education sector, academics at many universities have worked very closely, generating enhanced learning opportunities for students and consortium funding. The collegial spirit fostered by EWB-A helped to create cohesion in a uniform development of HumEng and allowed continued and supported growth.

NCP funding

New Colombo Plan (NCP) Mobility Grant funding from the Australian Government is a key enabler of overseas programs such as the Design Summits. The NCP supports Australian undergraduate students to study in the Indo-Pacific Region to lift the knowledge of the region. Australian universities bid for funding through the program [29]. As an example, these scholarships usually cover 80% of EWB-A program participation costs, enabling broader student participation, while still requiring financial commitment from the students. Almost AUD 5 million has been successfully awarded to programs with Humanitarian Engineering outcomes since the program began in 2014.

NCP grants have fostered an educational experiences market, with organisations such as Unbound, Pollinate and Project Everest emerging. However, the future of the grant system is unpredictable, and the dependency on funding creates an unstable educational model. Furthermore, NCP funding is only open to Australian citizens, meaning many international students studying at Australian universities are excluded from such opportunities. Further, the value provided to communities involved in these overseas programs is being assessed, as it is not always mutual, as discussed by Birzer and Hamilton [30].

Curriculum renewal

To accommodate the 21st century requirements of an engineering professional, many Australian universities are reviewing and renewing their engineering curriculum. As many universities embed project-based and problem-based learning throughout their degree structure, it creates opportunities to apply engineering to a broader range of fields, such as HumEng and development. The greater emphasis on application-based learning creates space and potential relationships and partnerships with community organisations and development organisations. This also complements the trend of students undertaking double degrees, combining engineering with another area such as Arts or Commerce, where HumEng projects can tie into other areas across the university and within students' study.

Future Challenges and Opportunities

The growing body of Humanitarian Engineering in Australia presents unique opportunities and challenges. The first of which is a unified body of knowledge. With many universities beginning to create programs in HumEng, multiple interpretations and definitions may emerge. Already a contested field with multiple interpretations in the US, Australia has a unique opportunity to create a cohesive definition through collaboration and consultation with key university and industry stakeholders. This may help HumEng develop into a discipline or area of practice, as opposed to a number of unique specialisations. The sector can be strengthened by multiple approaches and applications of HumEng, creating roles in new areas and diversifying the field. However, the benefits of a unified message publicly creates clarity and a cohesive brand, working to further promote and expand upon the increasing awareness of the field.

Another key challenge and opportunity is to allow the term and field to continuously evolve and grow without restrictions. Already, EWB-A have transitioned to a model of human-centred engineering, as opposed to explicitly Humanitarian Engineering. This prompts questions regarding the viability of the specific term continuing, as many are using terms such as socio-technical thinking and human-centered engineering. Alternately, the evolution of new terms and definitions could sit under the banner of Humanitarian Engineering, or could evolve outside, perhaps shifting the definition of Humanitarian Engineering as well and expanding the field.

Education quality assurance

Quality assurance of HumEng offerings and programs is paramount as they continue to expand. A level of comparable standards may be required to ensure the continued development and quality of the educational offerings, and in accordance with recent development and design practices. Academic channels such as journals and conferences could be the driver of assurance in the field. It presents an opportunity for academics and practitioners to critique and share their models in journals such as the Journal of Humanitarian Engineering, and Development Engineering, or could be managed by HEENA or other organisation.

Professional practice

Currently, the number of students seeking employment in traditional HumEng fields of aid and development far exceeds the demand. This calls into question the relevancy of curricula that prepare students for this path, in turn creating an opportunity to expand the current offerings and diverse career paths in HumEng. As students translate their experiences with HumEng into a traditional workplace, the principles and practices may integrate into other fields of engineering. University courses can also support students to understand the translation of their HumEng skills and knowledge to a traditional engineering role.

Lessons for other countries

The experiences and development of Humanitarian Engineering education in Australia was influenced by countries with established fields and programs, such as the US, UK and Canada. This growth in Australia can help inform other countries and institutions looking to provide offerings in the area. Some key lessons and recommendations are:

- **Collegial spirit:** approaching the development of HumEng with an open and communicative perspective. Universities are stronger and can create broader discipline and structural change when acting in partnership and sharing ideas, proposals, funding, courses and subjects.
- **Forums for communication:** establishing a formal or informal group or network of academics and professionals who are interested in the area, opening platforms for communication and critiques.
- **Central body:** a network or organization could be the central body and repository of knowledge. In Australia's case, EWB-A was the central body defining and promoting the field, working with universities, and providing educational opportunities. In the early phases, this can also create a cohesive understanding of the field, allowing a clear brand to be formed. As the field grows, this central body can act as a place where various understandings and branches of the field can meet, diversifying the original definition and understanding.
- **Appropriate term:** the term Humanitarian Engineering was first promoted by the main accrediting body, Engineers Australia. However, there has been discussion about the appropriateness of the term and if something else should be used e.g development engineering or technology for human development. More recently, EWB-A has shifted to the term human-centered engineering. As a field continued to evolve or emerge, discussion of the suitability of a term, as well as the meaning is integral.
- **Education:** awareness of HumEng and the increasing number of graduates pursuing careers in the area has largely been driven by education opportunities. Embedding programs like a first year design challenge, as the EWB-A Design Challenge has been in Australia, provides students insight into what HumEng looks like. Student interest can then be maintained through planned engagements in future subjects throughout the degree in engineering or in other complementary faculties. Formal programs such as specializations, Diplomas, minors, and majors can also help to establish pathways for students and provides formal recognition of their interest.

- Research: documenting the advances, educational opportunities and outcomes creates a body of work and evidence of the benefits of HumEng skills and attributes. Sharing educational outcomes and research on HumEng work raises the profile of the field, and generates conversation as education conferences and within the academic community.
- Domestic: in Australia, the educational opportunities are predominantly international. However, this does not reflect the work organisations like EWB-A are doing with Australian communities. When defining HumEng or the equivalent field, consider the domestic and international contexts and how those can be emphasized through educational content.
- Professional recognition: formal or informal recognition through accrediting bodies or leadership forums provides legitimacy and supports both bottom-up and top-down change.

Conclusion

Humanitarian Engineering in Australia has experienced many successes in the previous two decades through promotion, recognition and education. Organisations and collaborations in the field have been paramount to the promotion and advancement of the area. Current and future advancement will also be driven by the education sector, creating new understandings and applications of the field. Key challenges of creating cohesion, ensuring quality control across educational offerings and the professional practice of the field are emerging. Open collaboration and discourse will help to ease these tensions and create greater understanding and application of engineering to underserved populations. The momentum of Humanitarian Engineering in Australia looks set to continue, creating new opportunities for students and professionals working for prosperity of communities globally.

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