The Rise of Humanitarian Engineering Education in Australasia

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SESSION S3: Integrating Humanitarianism in Engineering Education

CONTEXT Since the early 1980's, numerous organisations seeking to utilise engineering to address humanitarian and development challenges have been established including Engineering for Change, Engineers Against Poverty, Engineers for Overseas Development and national Engineers Without Borders and RedRs. This has contributed to the growth of humanitarian engineering education programs and initiatives in countries including the USA, UK and Canada from the early 2000's. Similarly, humanitarian engineering education courses and initiatives have been established in Australian and New Zealand.

PURPOSE This paper details the growth of humanitarian engineering education programs and initiatives in Australasia since 2006 leading to the current state of the field. From this opportunities for further growth and development will be identified.

APPROACH Student and university participation data drawn from national programs as well as details of current and planned university offerings is used to identify the growth in humanitarian engineering education in Australia and New Zealand. Outcomes from a collaborative cross-institutional workshop are used to identify priorities and opportunities for growth and development.

RESULTS Although isolated initiatives have been delivered under a variety of terms, the current growth of humanitarian engineering education dates back to the launch of the EWB Challenge in 2007. Since 2015 there has been a dramatic increase in the scale of offerings and engagement with the establishment of the EWB Humanitarian Design Summits and introduction of Australian Federal Government support for mobility programs. This has led to the development of elective courses in the area and formal award programs emerging from 2016, with at least five Australasian universities offering or planning award programs. Broader impact is demonstrated by student demographic data which clearly indicates a significantly higher percentage of female engagement in the area than typical for engineering.

CONCLUSIONS Opportunities exist to continue to expand the field and its impact including educational research and development, engagement with professional bodies, and advocacy. This will contribute to leadership and the potential for humanitarian engineering to achieve positive impacts for communities and individuals in Australasia and internationally.

KEYWORDS Humanitarian engineering, development engineering, graduate outcomes

Introduction

The role of engineering in national development and providing benefits to society has been articulated since the first civilian professional associations began in the early 1800's (Institute of Civil Engineers, 2017). The engineering profession has sought to bring these benefits to various short- and long-term humanitarian interventions as part of the growth of coordinated responses and international development since the 1960's (Lucena and Schneider 2008). From the early 1980's this led to the establishment of dedicated organisations utilising engineering to address humanitarian and development challenges including Engineering for Change (EfC), Engineers Against Poverty (EAP), Engineers for Overseas Development (EOD), national Engineers Without Borders (EWB) and RedRs (UNECSO 2010). These organisations work across the humanitarian spectrum, from immediate disaster response, through recovery and stabilisation, to long-term community and infrastructure development, disaster planning and preparedness, and capacity building (Greet 2014).

Many of the engineering organisations working in development were established by engineering students or university staff. This has contributed to the growth of humanitarian engineering education programs and initiatives in countries including the USA, UK and Canada, which engage students in the area and prepare them for future roles (Lucena and Schneider 2008, UNECSO 2010). In Australasia, individual courses and initiatives within humanitarian engineering education were established in the early 2000's and have been growing since 2007.

This paper reviews the integration of humanitarianism in engineering education in Australasia and details the growth of humanitarian engineering education programs and initiatives since 2006. It first discusses humanitarian engineering including a working understanding of the term and overview of some of the key organisations. Data on university and student engagement is provided from national programs and university offerings. Finally, opportunities, challenges and priorities for continued growth and support are identified.

What is humanitarian engineering?

The term *humanitarian engineering* (HumEng) only emerged in Australasia with Engineers Australia's, the peak professional body, *Year of Humanitarian Engineering* in 2011. Prior to that, terms such as *development engineering* were used (Turner et al. 2015). The first reference to the term at an Australasian Association for Engineering Education (AAEE) conference was in 2013, previously *EWB* was used as a synonym for the field.

The understanding of HumEng that has emerged in Australia since 2011 encompasses a wide range of contexts and locations, from disaster response through to community and technology development, both internationally and domestically. HumEng is taken as the application of an engineering discipline, such as civil or mechanical, to a specific humanitarian or development context or response. In this way, it is an application area requiring additional dedicated knowledge, skills, attitudes and competencies rather than a unique discipline. This is a broader understanding than other countries, for example in the USA HumEng encapsulates predominately non-US development while in the UK it focuses on disaster response and recovery. (Turner et al. 2015)

While there has always been individual *humanitarian engineering education* (HumEngEdu) offerings available to students, the first structured programs providing multiple engagements emerged from universities in the USA in the early 2000's (Bixler et al. 2014, Dean and Van Bossuyt 2014). In Australasia, a small number of not-for-profit organisations have been leading the development of education and training initiatives in the area. RedR Australia was established in 1992 to make engineering available to disaster relief and has since expanded to offer expertise across all aspects of humanitarian emergencies (RedR Australia 2017). RedR has offered short-course professional development training since 1998 and has

recently expanded to support tertiary education and as of mid-2017 has partnerships with five Australian universities across a range of humanitarian response aspects, not only engineering (RedR Australia 2017).

The first wide-scale HumEngEdu offerings in Australasia were developed by Engineers Without Borders Australia (EWB-A). EWB-A, which was established as an independent national organisation in 2003, has a focus on community development in Australia and the surrounding region. EWB-A delivers three programs (discussed below) targeting tertiary education. Engineers Without Borders New Zealand (EWB-NZ), another independent national EWB organisation, established in 2008, provides three programs to universities in NZ. Since 2016, further offerings have emerged in Australasia. The first Australian chapter of Engineering World Health (EWH), a US-based organisation to improve healthcare delivery in low-income countries, operates at the University of New South Wales (Engineering World Health 2017). The Laika Academy provides short-term study abroad opportunities covering topics interfacing with HumEng including design for social change, sustainable development, social enterprise and community rebuilding (Laika Academy 2017).

Humanitarian engineering education in Australia and New Zealand

The opportunities provided by external organisations are incorporated into universities programs as institutions deem appropriate. Universities expand on those to develop their own opportunities depending on resources, expertise and demand. However, the largest programs, in terms of duration and reach, are those offered by EWB-A which are detailed below. Data from the EWB-A programs combined with a summary of university courses and programs, will be used to investigate the overall scale of HumEngEdu in Australasia. While this data will not be comprehensive, it will provide an indication of growth and overall trends.

The EWB Challenge

The EWB Challenge, coordinated by EWB-A, is a design program delivered in partnership with universities which introduces concepts of humanitarian engineering to students in addition to crowd sourcing ideas for community based organisations. Each year the EWB Challenge focuses on projects identified in conjunction with one of EWB-A's community based partner organisations. The EWB Challenge provides a platform that enables universities to meet learning outcomes associated with global citizenship, professional practice and sustainability. Universities embed the EWB Challenge into first year engineering curriculum, typically within an introduction to design or engineering unit, adapting the program to meet the learning outcomes of the unit in which it is embedded.

The EWB Challenge has arguably been the most influential program contributing to the rise of HumEngEdu in Australasia. The EWB Challenge was introduced at a time of increased pressure to renew first year engineering curriculum and adopt education pedagogies such as project based learning to meet changing education demands (Jolly 2014). The EWB Challenge provided real world project briefs and supporting resources, such as data, photographs and report marking criteria, making it appropriate for universities to embed. The EWB Challenge provided a common platform for universities to compare and evaluate their approaches to first year engineering education as seen in a 2014 Office of Learning and Teaching report by Jolly (2014):

> "The Challenge is unique [at the time of the evaluation] for engineering in that, like some approaches in medicine, agriculture and elsewhere, it has a strong and distinctive focus on the development of graduate attributes related to social, cross cultural and ethical responsibilities in a global context." (Jolly 2014)

The EWB Challenge was launched as a national program in 2007 in partnership with 21 universities and reached approximately 3,500 students, see Figure 1 A). It rapidly expanded

and in 2017 reached 9,040 students at 28 universities including the off-shore campuses of Australian institutions, and remains the largest HumEngEdu initiative in Australia and New Zealand. In 2011 the EWB Challenge program was introduced to the UK where the program, referred to as the Engineering for People Design Challenge, is co-ordinated by Engineers Without Borders UK (EWB-UK). In 2016/2017 this reached 4,600 students across 23 universities (EWB-UK, 2017). The EWB Challenge was supported by university registration fees subsidised by sponsorship from BHP Billiton Sustainable Communities from 2008 to 2015. Since then the program has been funded solely by university registration fees.

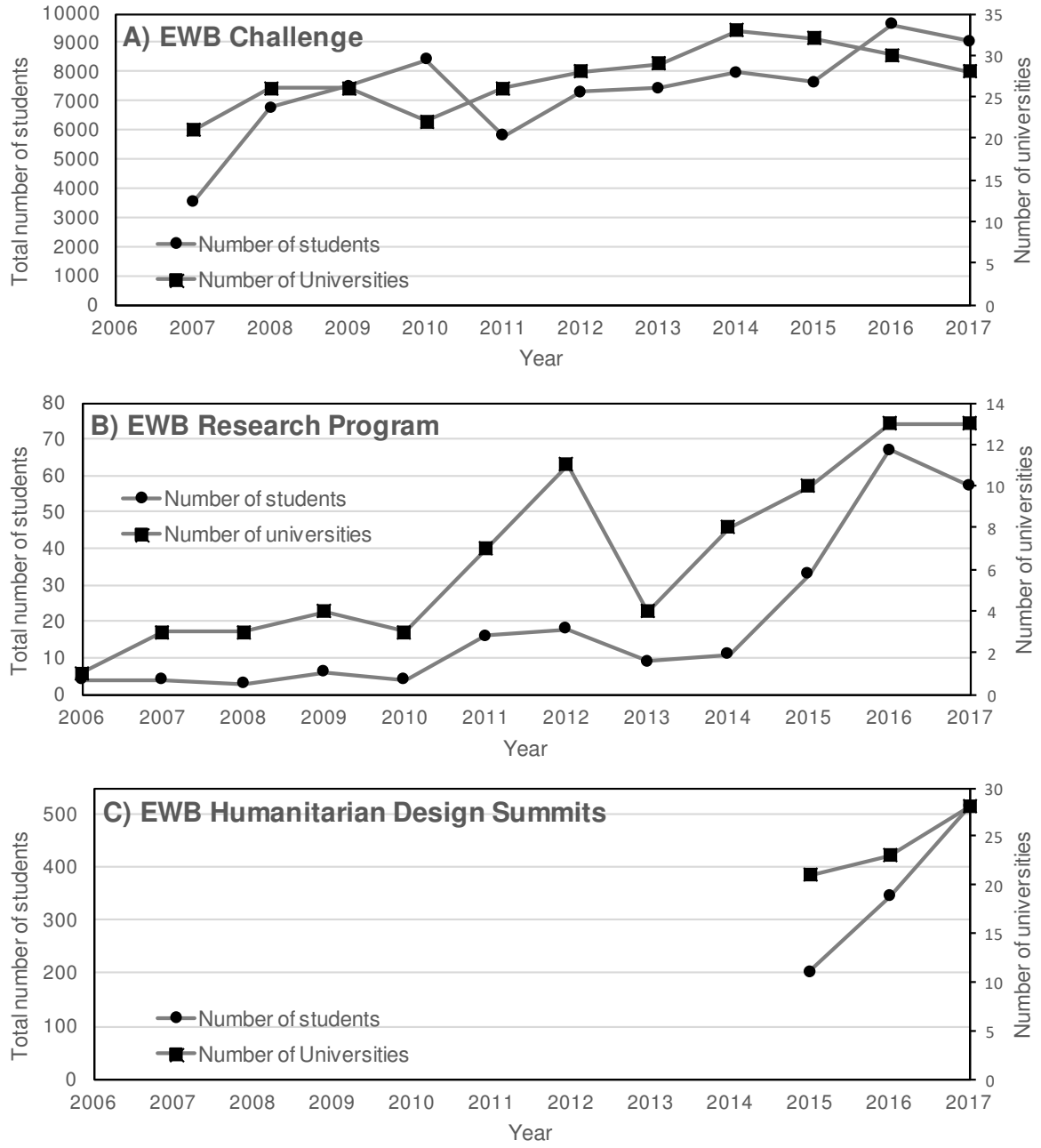

Figure 1: Total number of students and universities in Australasia participating in A) the EWB Challenge, data supplied by EWB-A from university registrations where universities self-report student numbers, B) the EWB Research program, data supplied by EWB-A from student registrations and C) the EWB Humanitarian Design Summits, data supplied by EWB-A from student registrations. (Note: data for 2017 is estimated)

EWB University Research Program

The EWB University Research Program, established by EWB-A in 2006, engages students, academics and community organisations in collaborative research projects. Beyond the development of new humanitarian knowledge and technologies, the program provides university students with an opportunity to grow humanitarian skills and social impact motivation before entering the workforce. The real-world context is vital with all projects targeting opportunities identified by practitioners and community development organisations working towards sustainable development in the Asia-Pacific region. The EWB University Research Program has conducted over 200 collaborative research projects in total as shown in Figure 1 B). In 2017, the program was delivered in partnership with 13 universities engaging 57 undergraduate researchers. The program was initially run through volunteer support while since 2009 the program management has been part of a paid role. A similar program is supported by EWB-NZ targeting universities in NZ.

EWB Humanitarian Design Summits

The EWB Humanitarian Engineering Design Summit program is a short-term study aboard opportunity designed to provide students with an experience to develop a deeper understanding of the role design and technology plays in creating positive change within communities. Students work through a human-centred design cycle over two weeks culminating with presentations of ideas to community members and organisations. A key component of the learning is ensuring that students participate in a genuine, immersive rural experience with a community. To deliver the program EWB-A partners closely with local grass-roots organisations that have a working relationship with communities.

The program was inspired by the hands-on International Development Design Summit at Massachusetts Institute of Technology's (MIT) D-Lab, leaders in human-centred co-design and community creative capacity building. Recognising the need for professional practice training and building on the experience of EWB's previous pilot study-tours, the Humanitarian Design Summit was launched 2015. The program has expanded to deliver 12 programs a year in six countries and has a network of over 800 alumni with university and student participation shown in Figure 1 C). The program collaborates with more than 25 Australian universities and is recognised through the Australian Government New Colombo Plan. EWB-NZ also runs similar opportunities for New Zealand university students.

Measured learning outcomes for students include development of personal and professional skills, application of knowledge in a development context, recognition of development practices and use of human-centred principles. The program delivers outcomes through workshop sessions, cultural immersion activities and student-led investigations. The program includes Academic Fellow positions allowing university staff to participate and gain first-hand experience in humanitarian contexts, which they can utilise within their teaching practice (Brown et al. 2016).

University humanitarian engineering offerings

Current and planned HumEngEdu course and program offerings from a range of Australasian universities are shown in Table 1. This is not intended to be a complete list and is provided from institutions involved with the Humanitarian Engineering Education Network of Australasia (described below). It focuses on university level tertiary education only, excluding the VET sector and professional development. This includes the two currently available award programs at the University of Canterbury and the University of Sydney.

Most of the universities engaged with HumEngEdu, shown in Figure 1, are involved with more than one initiative with the overall number of universities in Australasia involved with HumEngEdu in the order of 30. This means at least 60% of the universities offering engineering in Australia and NZ are involved with HumEngEdu in some form (EA 2017, Education NZ 2017). From Table 1 at least five of these universities currently offer, or plan to

offer, award programs under the term Humanitarian Engineering. All of these award programs are complementary, or added, to an existing bachelor's degree in engineering, mostly commonly in the form of a four-unit program (called a minor or major depending on institution). This aligns with the understanding of HumEng in Australasia, as the conscious application of a base engineering discipline to humanitarian contexts or responses.

Table 1: Selection of humanitarian engineering education university offerings, including current status of proposed or planned programs

University	Offering	Structure	Status / notes
The Australian National University	Master of Humanitarian Engineering	Proposed vertical double degree with a Bachelor of Engineering.	Proposed, if approved would be available from 2019 to all engineering students.
RMIT University	Elective course in Master of Engineering	12-credit point, first year dedicated humanitarian engineering elective	Currently offered.
Southern Cross University	Compulsory course in Bachelor of Engineering	12-credit point, first year compulsory course.	Focuses on a humanitarian engineering project (independent of the EWB Challenge).
Swinburne University of Technology	Social Impact Pillar and compulsory service learning in Bachelor of Engineering Practice	Social impact is one of 4 compulsory pillars. 15% of student workload is dedicated to service-learning project work.	Bachelor of Engineering Practice commences in 2018 and integrates social impact across the degree rather than a separate focus.
The University of Adelaide	Minor in Humanitarian Engineering	Six courses, 2 as double-badged, 4 dedicated courses from a list of 7.	Approved to commence in 2019 available to all engineering students.
University of Canterbury	Diploma in Global Humanitarian Engineering	Mix of cross-credit courses, non-engineering electives and capstone course	Commenced in 2016.
The University of Melbourne	Minor in Humanitarian Engineering	Within the 2-year Master of Engineering.	Proposed, if approved would be available from 2019 to all engineering students.
The University of New South Wales	Courses in Humanitarian Engineering	Two new humanitarian engineering focused courses.	To commence 2018, available to all engineering students.
The University of Sydney	Major in Humanitarian Engineering	Four compulsory courses (3 engineering, 1 arts).	Commenced 2017, first graduates expected 2018, available to all engineering students.
University of Wollongong	Scholars Research Project	6-credit unit course.	Students undertake field work in Rwanda.
University of Technology Sydney	Summer Intensive Design Studio	Design studio focused on humanitarian engineering.	To be offered for the first time in the 2017/18 summer session.

Impacts of humanitarian engineering education

The growth of HumEngEdu has already had impact on engineering education and professional practice in a number of positive ways. One of the strengths of HumEngEdu is a greater level of engagement of female students. Female participation in the EWB University Research program since 2006 is 38% while the female participation in EWB Humanitarian Design Summit since being recorded from mid-2016 is 45% (data supplied by EWB-A). Female applicants make up 41% of the total EWB Humanitarian Design Summit applications, suggesting female applicants are more likely to be accepted as they are of higher quality and articulate stronger motivation statements. These compare to female participation of 12.4% of the engineering workforce and the 15-20% common in undergraduate engineering studies (Engineers Australia, 2017). Similar trends are seen at individual institutions, for example at the ANU female participation in optional or elective HumEngEdu since 2007 is 33% compared to an overall female participation of 22% (data supplied by ANU).

Another strength of HumEngEdu is its alignment with recent changes to the portrayal of engineers and additions to Engineers Australia's strategic plan and purpose. To the purpose in their previous strategic plan (2014/15 - 2016/17), "*We are the global home for engineering professionals renowned as leaders in shaping a sustainable world*", the 2017/18 - 2019/20 strategic plan has added *"Engineers Australia shapes the future of Australia - creating happy, healthy, prosperous and sustainable communities*" along with a strategy to "*advance the science and practice of engineering for the benefit of the community*" (EA, 2017a).

Across the growth of HumEngEdu a number of limitations and challenges have been encountered. One of these, the cost of participating in immersive study experiences such as EWB Humanitarian Design Summits, has been eased through the Australian Federal Government New Colombo Plan (NCP) scholarships. Launched in 2014, these are designed to support experiences in the Indo-Pacific and have certainly contributed to the growth of programs offered by EWB-A and the Laika Academy. However, NCP scholarships are limited to domestic students and may still leave a significant funding gap for some students.

As highlighted in international research (such as VanderSteen et al. 2009), another challenge is the ethics and appropriateness of students engaging in development and community work. This must continuously be considered, in particular in relation to resources committed and outcomes received by the parties involved. Considerations are taken into account through the design of programs, with students in the EWB University Research Program and EWB Humanitarian Design Summits only engaging in development through scaffolded and mentored experiences and not independently leading a project. The understanding of HumEng within Australasia emphasises not only international work, as in some countries, but highlights domestic development challenges and inequities.

An early challenge in HumEngEdu in Australasia was the expertise of academics and educators, with many coming from engineering backgrounds with little or no development experience. The Academic Mentor roles within EWB Summits were designed with this in mind, to provide field experience, while further capacity is being built through annual EWB Challenge academic workshops, dedicated HumEng academic positions, the establishment of network of educators (see below) and the expertise provided by EWB-A and RedR.

Opportunities and recommendations for the future

To support the growth of HumEngEdu, the Humanitarian Engineering Education Network of Australasia (HEENA) was formed at the start of 2017. Involving more than a dozen universities this serves as a platform for academics, educators and practitioners involved with HumEngEdu initiatives to support one another, build on strengths and overcome limitations. In September 2017, this network held a half-day discussion exploring the growth of HumEngEdu, attended by eight Australian universities and two education providers. From this discussion, a number of priority areas were identified to support growth and delivery of

programs at individual institutions, continue cross-institutional collaboration, and demonstrate national leadership. The priority areas identified were:

1. The establishment of a national Advisory Board to provide advocacy, leadership and engagement for the further growth and development of HumEng.
2. Engagement with EA to ensure alignment of HumEng education, professional development and practice with EA structures, recognition and processes.
3. Education design and delivery, including the development and sharing of course material, curriculum approaches and education research. This will seek to build an evidence base to evaluate the impact of HumEngEdu on graduate employability and partners to support continuous improvement and best practice.
4. Research and funding, to support research and development in the area and opportunities for collaborations to support broader impact beyond education.

Many of these aims build on existing work in the area in Australia (such as Greet 2014, Smith et al. 2015, Turner et al. 2015) and internationally (for example Bixler et al. 2014, Dean and Van Bossuyt 2014, VanderSteen et al. 2009). They recognise that work and education in humanitarian contexts is highly complex and multi-disciplinary. In most cases, it involves engagement and work with potentially vulnerable and at risk individuals and communities requiring the highest level of ethical practice and conduct. A shared understanding of HumEng and its application is required to enable appropriate delivery of education, research, services and impact, which is a focus for HEENA. This will promote further growth aligning with the newly articulated purpose of EA and to create a new generation of engineers able, and willing, to emphasis positive community benefits in all engineering work.

Conclusions

Ten years after the wide-scale introduction of the EWB Challenge and EWB University Research Program, HumEngEdu is now common across universities in Australia and NZ. There has been a step-change in the integration of humanitarianism into engineering education since 2015 with at least 60% of universities in Australasia offering engineering involved in HumEngEdu in some form, two currently delivering award programs and at least three more planning award programs. This increase has been driven and supported by student interest, a recognition of the global nature of engineering, and new opportunities for students to be involved in study abroad programs. The increase has demonstrated impacts on gender diversity in engineering education with programs and initiatives typically reporting 50% or higher female participation than on average.

A network has been established by universities and organisations working in HumEngEdu to support its continued growth. This has led to priority areas being identified for further collaborations, discussions and leadership to ensure HumEngEdu is delivering on its potential to support student outcomes and achieve positive impacts for communities and individuals in Australia, NZ and internationally.

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