Background

Over the past eight years the number of initiatives within Australia focused on humanitarian engineering has grown. This has given rise to the need to develop a common understanding of the term humanitarian engineering within Australia as a basis for alignment and agreement on core competencies, skills and knowledge required to practice humanitarian engineering. Humanitarian engineering (HE) as a term has become widespread since the turn of the century. This has been driven by the rise of HE organisations, often not-for-profits, university education initiatives and academic publications. For example, numerous independent Engineers Without Borders (EWB) organisations have started since 2000 including EWB Canada (founded in 2000), EWB UK (2001), EWB USA (2002), EWB Australia (2003), EWB New Zealand (2008) and EWB-Asia (2014). HE education programs, centres or initiatives are established at universities including Coventry University in the UK (Hill and Miles, 2012) and Ohio State University (Passino, 2009), Pennsylvania State University (Dzombak and Mehta, 2013) and Colorado School of Mines (Leyden and Lucena, 2014) in the USA.

However within these organisations and initiatives a number of different meanings and understandings of HE exist. Passino (2009) highlights the role of technology development and voluntary service for humanitarian engineers, as either graduates or students. Campbell and Wilson (2011) provide a definition as “the application of engineering skills or services for humanitarian aid purposes, such as disaster recovery or international development” while Dzombak and Mehta (2013) emphasise “efforts to improve the wellbeing of marginalized communities with technology-based solutions”. These broadly consider HE as the application of engineering, in terms of technology development and associated processes and services, for humanitarian interventions. Within these programs interventions typically focus on international development and disaster response, reflecting the increase in global engineering and opportunities in USA engineering programs (such as Zoltowski and Oakes, 2014).

Under this definition other programs not labeled humanitarian engineering could also be considered. For example, the Engineering for Developing Communities centre at the University of Colorado Boulder has a focus on applying engineering for international (non-USA) developing countries (Amadei and Wallace, 2009). Development Engineering itself has been highlighted as a new field with a focus on technology interventions and design with an emphasis on complex, low resource, poor settings (Nilsson et al, 2014).

In the UK, HE has emerged from a more traditional understanding of humanitarian work as disaster response. However with the establishment and growth of organisations such as EWB-UK and programs including that at Coventry University a broader understanding is emerging. In data collected at Coventry University on students’ understandings of HE, Hill and Miles (2012) found the most important issues addressed by HE were “solving social problems” and “sustainability in developing countries”, with “poverty reduction” seen as less important. This highlights the view among students that HE is still commonly done ‘internationally’ rather than within one’s own country.

A different understanding of HE has emerged emphasising the impacts and consequences of engineering and technology for a community or individual, and the role they play rather than a focus on technology development. This seeks to address the disadvantage a community or individual faces, and seeks to achieve social justice outcomes. Leydens and Lucena (2014) provide a definition of social justice in relation to engineering as “engineering practices that strive to enhance human capabilities through an equitable distribution of opportunities and resources while reducing imposed risks and harms among agentic citizens of a specific community”. This focuses more on the outcomes seeking to be achieved rather than only the development of technology. However, as highlighted definitions of social justice are also dynamic and contested. Other works have sought to examine the context or location where

HE can occur. In contrast to many of the global or international HE initiatives in the USA, VanderSteen et al (2009) explores the benefits and ethics of such programs and highlights the role of HE in one's own community or location, particularly for engineering students.

In Australia the term HE was seldom used prior to 2011. For example, the 2010 strategy for EWB-Australia makes no mention of HE but instead refers to 'development engineering', while the organisations mission developed within two years of the strategy refers to 'humanitarian engineering' (EWB, 2015). The term emerged in 2011 with Engineers Australia's Year of Humanitarian Engineering (YoHE). This provided a definition for HE within Australia as "brings enhanced well-being, welfare, and comfort to any individual or community in disadvantaged circumstances and is inclusive of research, design, manufacturing and construction. The issues to be addressed in engineering terms might include chronic ongoing conditions for an individual or group, or be associated with high-impact disasters and emergencies which imperil large numbers of people." (in Greet, 2014). This highlights disadvantage as the key condition to be addressed and covers a range of contexts from long-term community development to disaster response. Greet (2014) takes this further highlighting HE as "a social concept which encourages improved employment and engagement of engineering resources, delivering humanitarian outcomes."

Understandings of HE were also explored in the documentary by Sheena Ong (Ong, 2014). This interviewed humanitarian engineers in Australia, considering that to encompass working domestically and international and in disaster response to community development. It proposed a number of definitions most of which are seeking to address disadvantage.

In all of these discussions HE is understood to be a complementary or parallel application of other disciplines of engineering. As a minimum it focuses strongly on understanding the context where engineering will take place and an additional skill set for engineering practice. These additional skills are often drawn from the social sciences, particularly development studies (Leydens and Lucena, 2014; and Nilsson et al, 2014), and business specifically social enterprises (Hill and Miles, 2012; and Dzombak and Mehta, 2014).

This paper aims to conduct research into the understanding of the term humanitarian engineering and to provide recommendations about how to achieve a consistent understanding of the term within Australia. This work will provide a basis for further discussions on alignment of competencies and learning outcomes in addition to informing new curriculum development in this field within Australia.

Humanitarian Engineering Education Initiatives

Although humanitarian, or development, engineering has not been embedded into engineering curriculum in the same way that sustainability has been, there are a number of standalone programs dedicated to its education. The most established tend to be found in the USA; examples include Humanitarian Engineering at the Colorado School of Mines, which is entering its second decade, and the Engineering for Developing Communities program which started in 2003 at the University of Colorado Boulder. Both of these offer specific programs including a mix of course-work and service-learning opportunities. The EPICS program (Engineering Projects in Community Service), which started at Purdue University in 2003 but has expanded to other institutions, also provides service-learning opportunities to engineering students (Coyle et al, 2005). Two HE courses offered by the Humanitarian Engineering Centre at Ohio State University (U.S.A) prepare students, through the teaching of the theory, to be professional humanitarian engineers (Passino, 2009). To complete a minor in humanitarian engineering students are additionally required to take part in service-learning programs, locally or internationally. In the UK, Master of Science programs are available including Humanitarian Engineering and Computing at Coventry University, and Engineering for International Development at University College London. Other universities, notably Manchester University and Cambridge University, have courses

focusing on International Disaster Management and sustainable development respectively, which contain aspects of humanitarian engineering.

Within Australia, many of the recent humanitarian engineering education (HEE) initiatives have been developed or supported by Engineers Without Borders Australia (EWB). The EWB Challenge aims to introduce concepts of HE to students. Delivered in partnership with EWB UK and EWB NZ, the EWB Challenge currently has a global reach of over 10,000 students through first year courses at 58 universities. Final year undergraduate students at Australian universities are able to take part in EWB's Humanitarian Engineering Research Program, established in 2009. Research projects are generated by community development organisations to support their work. In early 2015 EWB established its Humanitarian Design Summit program that enables undergraduate students to take part in an immersive cultural and participatory design experience based in Cambodia and led by experienced facilitators and academics.

In addition to the programs offered by EWB there are a number of related, dedicated courses at universities around Australia. The University of Western Australia (UWA) offers two courses (as outlined in Baillie and Armstrong, 2013) related to engineering for social and environmental justice, Global Challenges in Engineering (a compulsory first-year) and Critical Theories of Technological Development (an elective unit). At the University of Wollongong (UoW) a current OLT project on Integrating Indigenous Student Support through Indigenous Perspective Embedded in Engineering Curricula is leading towards a course in Indigenous Engineering (Goldfinch et al, 2014). The School of Health at Charles Darwin University runs a Master of Emergency and Disaster Management, which focuses on the management side of humanitarian work.

Approach

Based on the range of definitions identified from literature, a survey was developed to gain an understanding of the term *Humanitarian Engineering* in Australia. This focused on three key areas:

1. the areas HE's may have a role to play in;
2. the contexts HE's may have a role to play in; and
3. the activities HE's may have a role to play in for the areas and contexts identified.

The areas, contexts and activities listed in the survey questions were compiled from existing definitions of humanitarian engineering in the literature. This allowed participants to highlight any of the existing definitions along with combinations of those. Engineering and humanitarian background was surveyed along with basic demographic information. The ethical aspects of this research were approved by the Australian National University (ANU) Human Research Ethics Committee. The survey was disseminated through engineering education and professional networks.

At the time of writing the survey had been completed by 119 participants. Of the survey participants 80% had an engineering background, 55% were students studying for an engineering degree, 40% had completed the EWB Challenge at university and 26% had watched Ong's documentary. While the majority of the survey participants identified as having an engineering background only 45% had been involved with what they considered humanitarian work or assistance (paid or voluntary).

As highlighted in Figure 1, the majority of survey respondents considered HE to have a role to play in all the areas listed. However of these areas "economic development or wealth creation" and "addressing systematic inequality" stand out with 47% and 45% respectively of respondents considering HE to play a minor role only. The majority of survey respondents considered HE to have a role to play in all contexts with "developing countries" and "rural and

remote locations" standing out with over 94% and 88% respectively of respondents considering HE to play a major role. In contrast "urban environments" stands out as a context where HE plays the least role with 47% of respondents considering HE to only play a minor role. For the areas and contexts selected the majority of survey respondents considered HE to have a role to play in all activities listed. Standing out as activities were "applying engineering", "design under social and environmental constraints" and "'problem-solving" with over 90% of respondents considering HE to have a role to play for all three activities. This is probably not surprising considering that these activities overlap most with a traditional definition of engineering. In contrast the activities where HE was considered to have the least role to play were "provide compassion and care" and "promote and seek social justice" with 53% and 45% of respondents considering HE to only have a minor role to play respectively.

A	Poverty alleviation	H	Economic development or wealth creation
B	Disaster or emergency response	I	Addressing systematic inequity
C	Solving complex social problems	J	Working with marginalised, under-served or vulnerable
D	Global (cross-national boundaries) engineering work	K	Solving endemic global problems
E	Sustainable community development	L	Infrastructure development
F	Improving circumstances of injustice or inequity	M	Meeting basic (physiological) needs of all
G	Disaster preparedness	N	Education, training or capacity building

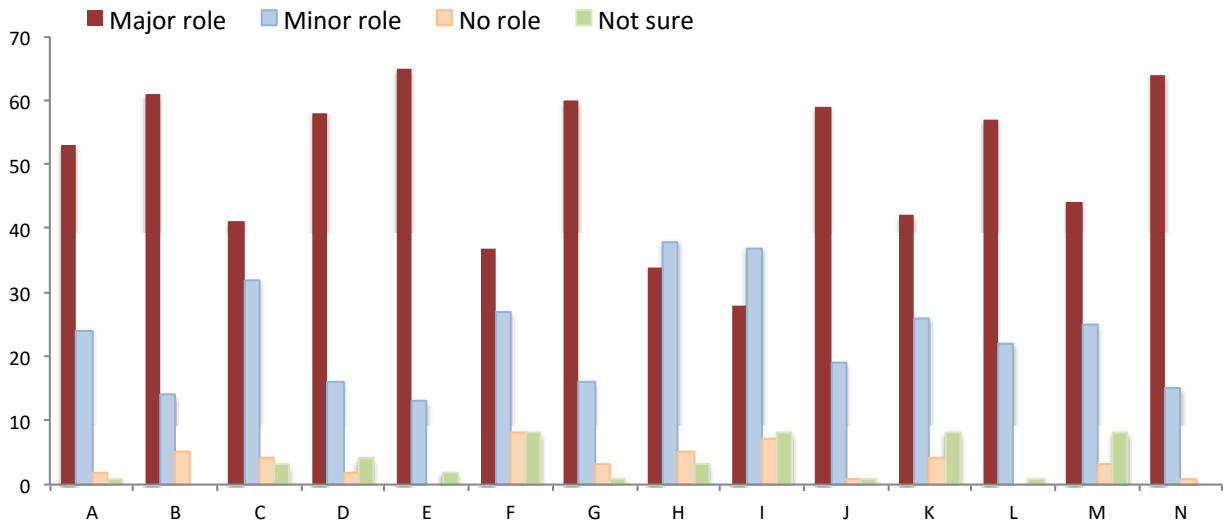

Figure 1 – Results of the understanding of the term humanitarian engineering survey showing what *areas* humanitarian engineers have a role to play in

When asked if HE was a specific engineering discipline, such as chemical or mechanical engineering, or a subset to a specific engineering discipline 50% considered HE to be a subset of an engineering discipline and only 10% considered it to be a specific discipline unto itself. Of the 40% who selected other as a response the written responses include terms like "A values orientation that should underpin all types of engineering", "Each engineering discipline can be used in a humanitarian way", "Applying engineering solutions with a major consideration for the social impacts" and "'Supplementary' makes it sound like a cheap add on. But I think that it is not a discipline in itself (like Mechanical) but is definitely its own area of expertise. In a lot of ways, ALL engineering work should be undertaken with a touch of 'humanitarian engineering' in mind".

A	Developing countries	E	Overseas disaster impacted area
B	Remote or rural locations	F	Within their local community
C	Urban environments	G	Overseas disaster prone area
D	Local disaster impacted area	H	Local disaster prone area

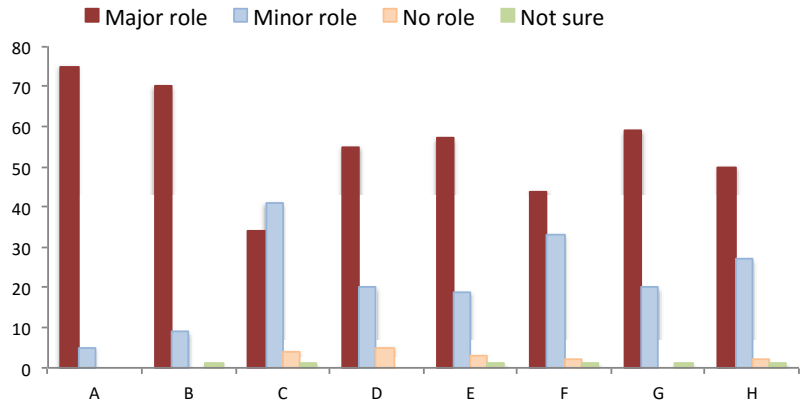

Figure 2 - Results of the understanding of the term humanitarian engineering survey showing what *contexts* or *locations* humanitarian engineers work in

A	Apply engineering (research, design, manufacturing, construction, …)	J	Conduct ethical practice
B	Provide compassion and care	K	Work to reduce imposed risks and harms
C	Design under social and environmental constraints	L	Promote enhanced or improved well-being, welfare and comfort
D	Engage and use natural and human resources	M	Promote human social and cultural development
E	Create improved employment opportunities or capabilities	N	Create technologies that help people
F	Implement long-term sustainable solutions	O	Promote equitable distribution of opportunities and resources
G	Empower individuals and communities to develop technological solutions	P	Problem-solve
H	Promote and seek social justice	Q	Promote stakeholder and end-user interaction, collaboration and engagement
I	Contribute to a culture of peace and a just existence		

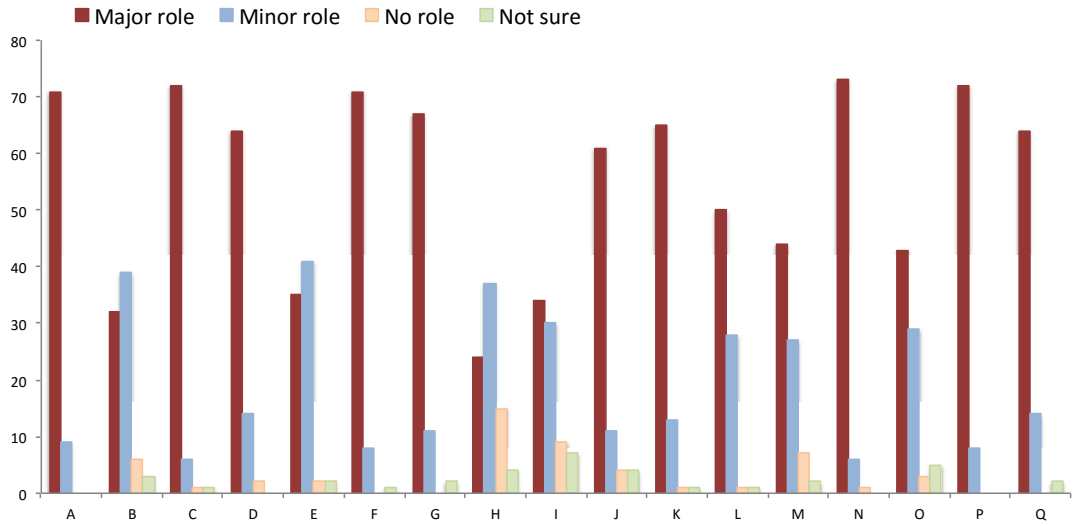

Figure 3 - Results of the understanding of the term humanitarian engineering survey showing the *activities* that humanitarian engineers conduct

Discussion

The results of the survey highlight the broader understanding of HE in Australia compared to other countries examined here. It appears to be generally understood to be engineers developing technology in rural, remote or developing communities for disaster relief or long-term development. Examining the range of understandings for areas where humanitarian engineers may have a role to play, HE was seen as having a major role for those related to disasters, technology development and community development. When considering the contexts or locations, HE was seen to have a major role in any disaster impacted or prone area as well as developing countries and remote or rural locations. The role was seen as less for urban environments or within the respondents' own community. This indicates less of a divide between international and domestic work as seen in many USA programs for example and reflects the views in the definitions developed for the YoHE and Ong (2014). This understanding should be incorporated into any HE course development, to ensure elements of both domestic and international assistance are including along with disaster response and community development while highlighting the need to incorporate to local, particularly urban, HE work.

Examining the results for the activities humanitarian engineers understood to be involved with, those related to social justice, peace and compassion were seen to have the least roles. The major roles were still identified as those most closely aligned with a view of engineering broadly around technology development and design under constraints. This highlights the need to ensure social justice elements are incorporating into HEE initiatives, as in the work of Baillie and Armstrong (2013) and Leydens and Lucena (2014). It should be noted the understanding and definitions of HE was limited to English-speaking developed countries. There is little description of HE seen in other countries, particularly developing countries where much of the HE efforts are focused. This should be explored further to gain an understanding of how HE is viewed from potential partners in developing countries.

Conclusion and Recommendations

This paper has documented the understanding of the term Humanitarian Engineering in Australia and has described the current state of Humanitarian Engineering Education in the domestic university sector. A number of recommendations have come from this research, some of which require the collaboration of interested universities in Australia. These recommendations relate to the sharing of curriculum resources between institutions, the sharing of initiatives between institutions and importantly the development of a framework for the requirements of formal HE qualifications. Specific recommendations are:

Recognition of HEE initiatives: A framework for recognising and assessing HEE offerings for any formal qualifications or recognition needs to be established. This should engage relevant organisations working in humanitarian engineering in Australia to establish requirements to which universities can align their offerings.

Sharing of curriculum resources: An open and mutually beneficial platform needs to be developed to promote sharing of material and resources across institutions.

Sharing of HEE initiatives: Courses are being developed at institutions based upon their strengths and expertise, such as engineering and social justice at the University of Western Australia and Indigenous engineering at the University of Wollongong. With HEE an emerging field many educators have little field experience and most no formal qualifications. Rather than replicating courses at institutions with a lack of expertise the opportunity exists to share HEE initiatives through cross-institutional study or a joint-programs.

In addition to the three recommendations above that specifically require collaboration there are two further recommendations:

Knowledge development for educators: support for development and training should be provided for interested educators. This could include field experience, which few educators have, and potentially a qualification. The new EWB Humanitarian Design Summit provides an opportunity for short term experience but other opportunities should be investigated.

Evaluation of HEE initiatives: Both the effectiveness and outcomes achieved through HEE initiatives need to be further explored and evaluated, in particular, students engaging with multiple initiatives across their degree programs, both for credit and extra-curricular activities.

References

Amadei, B., and Wallace, W. A. (2009). Engineering for humanitarian development. *IEEE Technology and Society Magazine*, *28*(4), 6–15.

Campbell, R. C., and Wilson, D. (2011). *The Unique Value of Humanitarian Engineering*, AC 2011-2701, American Society for Engineering Education.

Dzombak, R., & Mehta, K. (2014). Scholarly Advances in Humanitarian Engineering and Social Entrepreneurship: A Typology of Research Publications. *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, 98–116.

EWB (2015) http://www.ewb.org.au/about/ourstrategy last accessed August 19, 2015.

Goldfinch, T., Ilango, A., Roland, A., and Willis, J. (2014). *Australian Indigenous Culture and Heritage in Engineering Project Planning and the Implications for Engineering Education*. Proceedings of the Australasian Association for Engineering Education Annual Conference, Wellington, NZ.

Hill, S., and Miles, E. (2012). *What do Students understand by the term 'Humanitarian Engineering'?* Innovation, Practice and Research in Engineering Education, September 2012.

Leydens, J. A., and Lucena, J. C. (2014). Social Justice: A Missing, Unelaborated Dimension in Humanitarian Engineering and Learning Through Service. *International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship*, *9*(2).

Nilsson, L., Madon, T., and Sastry, S. S. (2014). Toward a New Field of Development Engineering: Linking Technology Design to the Demands of the Poor. *Procedia Engineering*, *78*, 3–9.

Ong, S. (2014). *The Humanitarian Engineering.*

Passino, K. M. (2009). Educating the Humanitarian Engineer. *Science and Engineering Ethics*, *15*(4), 577–600.

VanderSteen, J., Baillie, C., and Hall, K., 2009. International Humanitarian Engineering - Who Benefits and Who Pays? *IEEE Technology and Society Magazine*, Winter 2009.

Zoltowski, C. B., & Oakes, W. C. (2014). Learning by Doing: Reflections of the EPICS Program. International Journal for Service Learning in Engineering, Humanitarian Engineering and Social Entrepreneurship, 1–32.

Acknowledgements

Support for this project has been provided by the Australian Government Office for Learning and Teaching. The views in this project do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

Copyright