33rd Annual Conference of the Australasian Association for Engineering Education (AAEE 2022)
4 - 7 December 2022 – Sydney, NSW

Humanitarian Engineering Curriculum Development: A cross-School collaboration at Western Sydney University

Spyros Schismenos[a,b]; Garry J. Stevens[a]; Leigh Sheppard[b], Lynn Berry[b]; Ana Rodas[a]; and Surendra Shrestha[b]

School of Social Sciences, Humanitarian and Development Research Initiative (HADRI), Western Sydney University[a], School of Engineering, Design and Built Environment, Western Sydney University[b], Learning Futures, Western Sydney University[c]

Corresponding Author Email: spyros.schismenos@westernsydney.edu.au

ABSTRACT

CONTEXT

Humanitarian engineering is a compelling field of study for university students which provides inter-disciplinary education and training to address community challenges. Students in such programs typically learn about the value of socio-cultural knowledge in engineering thinking. However, engineering students do not always understand the importance of human-centered approaches and stakeholder engagement in socio-technical projects. Similarly, social sciences and humanitarian students focus largely on the non-technical aspects of a program mainly due to their lack of technical knowledge. Inter-disciplinary skills are highly valued and humanitarian engineering projects provide an opportunity to develop these thus benefiting students' career pathways.

PURPOSE OR GOAL

This paper presents a new inter-disciplinary initiative in humanitarian engineering education by Western Sydney University. The university has developed a new minor and subject in humanitarian engineering contexts with the support of academics and staff from both the School of Engineering, Design and Built Environment (EDBE), and the School of Social Sciences (SoSS). This program provides socio-technical skill development for a range of discipline groups across these Schools.

APPROACH

In this paper, the new minor and subject are outlined. The minor entitled *ENG0327 Humanitarian Action in Practice* includes five subjects: two First-Year subjects from EDBE; two *Second-Year subjects from* SoSS; and a new Third-Year subject entitled *HUMN3120 Humanitarian Design and Practice* currently being co-developed by EDBE and SoSS.

ANTICIPATED LEARNING OUTCOMES

An expected outcome of student learning in the new minor and subject is the development of inter-disciplinary skills for humanitarian engineering. Furthermore, students will practice these in real-life conditions in Australia and overseas via mobility programs.

CONCLUSIONS/SUMMARY

Cross-School education is critical for university students. By developing this new minor and subject curricular in the emerging field of Humanitarian Engineering, Western Sydney University highlights its strategic plan for inter-disciplinary education and training.

KEYWORDS

Humanitarian engineering, inter-disciplinary, engineering, social science, education.

Introduction

Humanitarian engineering is increasingly recognised as a field which, by its nature, is inherently inter-disciplinary. Engineers, social scientists and humanitarian workers play an important role in supporting the disaster preparedness of communities, and post-event relief and 'build back better' solutions to affected communities. The increasing impacts of climate change, such as severe floods and droughts, bring a sharper focus of the need for solutions led by communities, and requiring combined socio-cultural, environmental and technical knowledges (Arshad-Ayaz et al., 2020). Lucena et al. (2010) highlight the "problematic relationship" between engineers and communities when the former do not consider locals in the design and implementation of humanitarian and development projects. Literature shows that the lack of genuine engagement can lead to system failures and mistrust between engaging stakeholders (Schismenos et al., 2022b).

To increase success, national and international disaster relief organisations, including Engineers Without Borders, RedR, and United Nations agencies increasingly seek personnel with inter-disciplinary knowledge and skills that can support community resilience and humanitarian engineering programming. According to Turner et al. (2022), inter-disciplinarity is vital in education as "it involves the merging or integration of disciplinary knowledge to offer novel perspectives". Similarly, Evis (2022) describes inter-disciplinarity as a requirement of "integrated inputs from multiple, distinct disciplines to seek a resolution to, or an understanding of, one key issue".

The need for integrated knowledge in disaster management and community development is evident from the growing number of academic programs in humanitarian engineering that are offered by universities in Australia (e.g. Australian National University, University of New South Wales, University of Sydney) and overseas (e.g. Colorado School of Mines, Ohio State University, University of Canterbury).

According to reports by Engineering for Change (2019a, b), there is a growing number of subjects, minors and majors in institutions in Oceania and North America focusing on humanitarian engineering and related fields of practice. As of 2019, Australian universities offered one major, three minors and ten individual subjects related to humanitarian engineering (Engineering for Change, 2019a).

While there are many humanitarian engineering offerings around the country, it is important to note that most of the available programs primarily focus on engineering student cohorts. There is little evidence of programs or subjects for both engineering and social sciences students. Engineering students learn about community engagement approaches and their required 'soft' skills but these are commonly exercised in the 'kin' groups of fellow engineering students. They often lack the experiences and insights of other discipline groups that often have greater exposure to community development processes. To support genuine inter-disciplinarity, Western Sydney University (hereinafter, Western) developed a new minor and subject entitled *ENG0327 Humanitarian Action in Practice*, and *HUMN3120 Humanitarian Design and Practice*, respectively, in the inter-disciplinary field of humanitarian engineering. These are part of engineering, design, environmental, humanitarian and social sciences programs from both the School of Engineering, Design and Built Environment (EDBE) and the School of Social Sciences (SoSS). The following sessions present more information about each School and Western's philosophy on Indigenous and female participation in engineering as important elements for humanitarian engineering education (VanderSteen et al., 2010; Wilson et al., 2020).

School of Engineering, Design and Built Environment

The EDBE was established via the merger of the School of Engineering, and the School of Built Environment in 2021. The School comprises the key discipline areas of Engineering, Industrial Design, Architecture, Building Design and Management, Construction Management, and Project Management, with postgraduate offerings in many programs in addition to undergraduate. The EDBE operates across four campuses – Penrith, Parramatta South, Parramatta City Precinct, and the Sydney City Campus, and has ~4000 students. The School sits firmly within the Science,

Technology, Engineering and Mathematics (STEM) cluster of Western and is highly multi-disciplinary in its teaching and research activities.

Industry engagement is a strong feature of the EDBE with nearly all of the degrees offered being accredited at a national or international level. As such, industry engagement is a continuously performed activity and routinely involves program/subject development, industry-oriented research projects, student placements in industry, and industry mentoring. Many of these activities are coordinated via the operation of nine External Advisory Committees comprising industry and academic representatives.

Humanitarian engineering is introduced conceptually in the first year of EDBE engineering programs. It is delivered in partnership with Engineers Without Borders and challenges students to develop technical knowledge and skills to solve challenging developmental problems. However, the development of social engagement skills is a weakness which affords an important opportunity partner with the expertise available within the SoSS.

School of Social Sciences

The SoSS is a large and complex School, newly established on the 1st January 2020 following the deconstruction of the former School of Social Sciences and Psychology. The School sits within the Humanities, Arts and Social Sciences cluster and has 4700 students across four campuses – Parramatta South, Parramatta City, Liverpool, and Penrith. It offers 25 undergraduate and postgraduate degrees across its core disciplines of Anthropology, Criminology, Cyber Security, Development Studies, Geography, Sociology, Social Work, and Therapy Studies and Counselling.

In the 2022 Times Higher Education (THE) University Impact Rankings, Western was ranked #1 in the world for its initiatives and commitments to the United Nations' Sustainable Development Goals (SDGs). It was ranked 1st worldwide for SDG 6, Clean Water and Sanitation, and 3rd worldwide for SDG 5: Gender Equality (Western Sydney University, n.d.-b). The SoSS is a key contributor to this international standing through its strong research focus on diversity and human rights, urban heat and green infrastructure, and initiatives in humanitarian response, rehabilitation and development. The latter are concentrated within the School's Humanitarian and Development Research Initiative (HADRI) and its core streams of Disaster Preparedness and Response; Migration and Diaspora; and Sustainable Development and Human Security.

Western on Indigenous and Women in Engineering

Education sectors across the world have invested in programs to widen participation in an endeavour to increase student diversity in STEM degrees and careers with minimal impact (Ramiah et al., 2022). Diversity, equity and inclusion remain long-standing areas of concern in engineering education globally. In the Australian context, a research study commissioned by Engineers Australia reported that women make up 16% of Australia's engineering graduates, and 13% of the engineering workforce overall (Engineers Australia, 2022). Similarly, modest progress has been made at increasing Indigenous participation in engineering degrees with just 0.5% of total engineering students identifying as Aboriginal and Torres Strait Islander. This is significantly below population parity where 2.5% of the Australian population identify as Indigenous (Engineers Australia, 2022).

Acutely aware of the diversity and inclusion concerns in engineering education and careers, Western has developed a series of initiatives and strategies to encourage uptake, retention and employability of underrepresented groups in STEM, including the field of engineering specifically. For example, the Women in STEM Education (WiSE) Program aims to reshape the STEM workforce through, Employer Visits, WiSE Mentoring (Alumni-student mentoring), CareerHub – WiSE Site, and other career development workshops partnered with top employers including Amazon, Accenture and LinkedIn.

In 2020, Western introduced its Indigenous Engineering Aspire Program as part of the EDBE's commitment to widening participation. This is an internship program that aims to support the career

development of aspiring Indigenous engineers by connecting students with industry partners who offer mentoring, and workplace training. The program also offers global experiences and the option to join a 'talent pool' (Sardyga, 2020). Moreover, as part of its Indigenous Strategy 2020-2025, the EDBE has committed to doubling Indigenous student enrolments from 1.5% in 2021 to 3% by 2025 whilst also securing retention by doubling Indigenous student completions from 1% to 2% by 2025 (School Of Engineering, Design and Built Environment, 2020).

Approach

Why cross-School Education is important?

First-Year engineering students at Western interested in humanitarian and development engineering acquire the technical knowledge and skills to solve challenging local problems but frequently lack the social engagement skills needed to effectively implement such solutions. Community engagement skills are often more highly developed among social sciences students who are exposed to humanitarian and development practice during the Second-Year. However, social sciences students often lack the technical skills to directly address community challenges. This situation may be similar to other universities in Australia as well as overseas.

To address this imbalance, Western has developed a cross-School, inter-disciplinary minor that approaches humanitarian engineering practice by aligning the technical expertise of EDBE and the social science/community engagement skills of humanitarian and development teaching staff within SoSS. Importantly, the focus of this new offering is to attract a more diverse cohort of students including women and Indigenous students and other groups traditionally not attracted to engineering programs. This approach strongly aligns with Student Experience, Global Engagement, and Indigenous perspectives aspects of the EDBE Strategic Plan, and Western's Sustaining Success Strategic Plan 2021-2026 (Western Sydney University, n.d.-a), specifically:

- *Sustainability* - prioritise learning and research that promotes the United Nations Sustainable Development Goals and the sustainability of the environment; and
- *Transformation* - deliver transformative education and student experiences through innovative applied curricula, and proactive, customised engagement.

Cross-School education addresses an increasing need for professionals to work in international and inter-disciplinary contexts on complex problems and demonstrates the capacity for different disciplines at Western to collaborate to co-design and deliver strategic learning and overcome the structural barriers typical of many universities (Turner et al., 2022). The academic staff, industry partners and students involved in developing the minor and subject have been negotiating different ways of thinking and working which has benefitted from the inter-disciplinary expertise the first author (SS) has brought to the process.

ENG0327 Humanitarian Action in Practice Minor

The new minor consists of five subjects; four existing and one new.

Within EDBE, the concept of humanitarian engineering is introduced in two First-Year core subjects: *ENGR1024 Introduction to Engineering Practice*, delivered in partnership with Engineers Without Borders, and *ENGR1043 Co-Designing Change with Local Communities*, which focuses on human-centered design and development.

The SoSS offers two Second-Year subjects: *HUMN2017 Complex Emergencies and International Guidelines* which familiarises students in emergency and disaster management, and *BUSM2043 Project Management in Humanitarian and Development Studies*, which practices team and project management skills important for humanitarian contents.

The new subject *HUMN3120 Humanitarian Design and Practice* will be offered as a Third-Year subject withing the EDBE. It will allow students to practice both community engagement and prototype development skills using the framework of human-centered design. Through international and domestic mobility programs, including the New Colombo Plan and Erasmus+, students of this subject will collaborate with local communities in Oceania, Asia and Europe, regarding solutions for priority community needs. Figure 1 presents the minor and its subjects.

Figure 1: Visual presentation of the Humanitarian Action in Practice minor

HUMN3120 Humanitarian Design and Practice Subject

This subject will act as a capstone in the new Humanitarian Action in Practice minor and will draw on inter-disciplinary approaches (combining engineering, social sciences, humanitarian response, design and environment). It will focus on improving students' socio-technical skills and applying these to real-world humanitarian problems. A list of potential topics for students has been developed with local, national and international industry/community partners. Figure 2 visualises these in a 'Humanitarian Engineering Tree'. This Figure was developed following the mission and vision of Western in humanitarian engineering education and practice. All suggested topics accord with the principles of the United Nations Sustainable Development Goals (Colglazier, 2015) and the Sendai Framework for Disaster Risk Reduction (Pearson and Pelling, 2015).

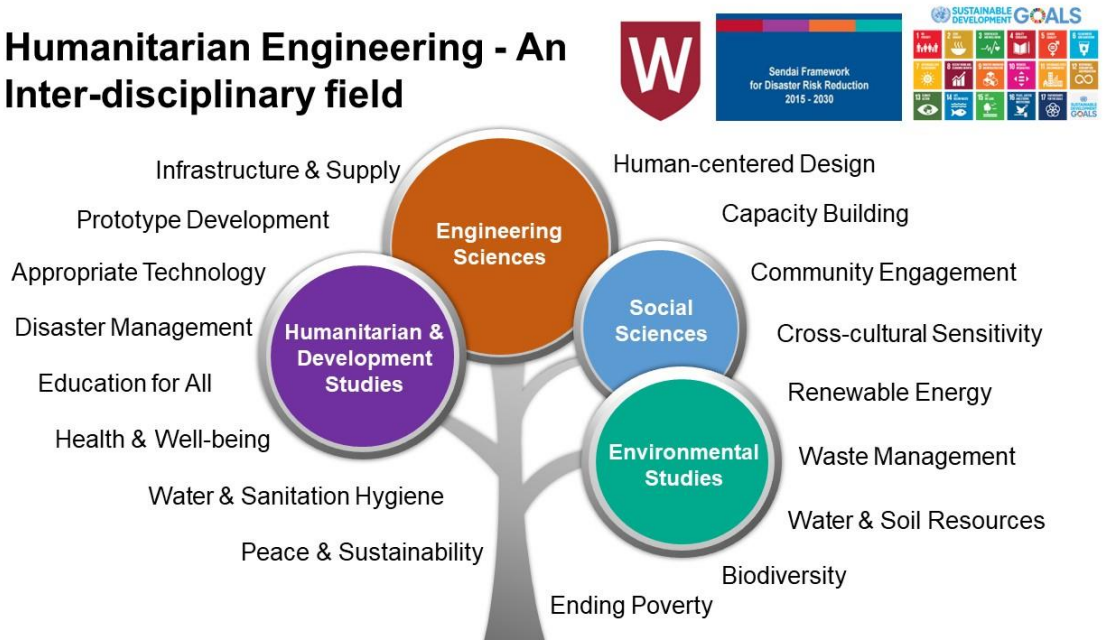

Figure 2: Humanitarian Engineering Tree – Humanitarian Design and Practice

The subject is currently being developed and expected to be available to students in 2024. All subject materials align with the Student Experience, Global Engagement, and Indigenous perspectives aspects of the EDBE Strategic Plan, as well as the SoSS Strategic Plan via Strategic Priorities: *(2)* preparing graduates for rapidly changing a globalised world; *(3)* enhancing opportunities for Indigenous students; *(4)* internationalising the School's curricula through strategic local, national and international partnerships.

Anticipated Learning Outcomes

The minor is expected to increase students' knowledge, skills, and the application of this knowledge and skills in humanitarian engineering and other related contents. It prioritises six learning outcomes:

1) Identification of different types of natural and human-induced disasters, their population impacts and management approaches.
2) Integration of inter-disciplinary aspects of modern humanitarian practice, including social, technical, environmental and economic facets.
3) Demonstration of communication and collaboration skills with a range of diverse audiences and in different formats.
4) Delivery of programs in community and humanitarian contexts using project management and leadership skills.
5) Systematic implementation of principles of community sustainable development and integrated disaster risk reduction at the local level.
6) Application of human-centered design approaches and community contextual knowledge to real-world humanitarian practice.

Similarly, the new subject aims to satisfy the following learning outcomes:

1) Analysis of the issues that affect sustainability in a design solution.
2) Identification of failure and success indicators of projects addressing community needs.

3) Application of systems approach towards the selection of socio-technical options for a given scenario.
4) Availability of socio-technical recommendations for community needs with appropriate justification.
5) Application of collaborative skills in a team setting to address a socio-technical problem.
6) Professional communication of methodology, analysis, and outcomes of a prototype idea/ development process in a range of different verbal and written formats.

Other humanitarian engineering initiatives at Western

Cross-School collaboration is highly promoted amongst post-graduate students at Western. The first author (SS), who is currently a PhD student at the university, developed a humanitarian engineering research topic that accords with what is being presented in this paper. With the support of academics from both SoSS and EDBE, and international partners in Greece (International Hellenic University) and Nepal (Kathmandu University), the student investigated how can remote, flood-prone communities in Greece and Nepal engage with each other to co-design and develop a prototype for renewable energy generation and flood early warning. Study findings and methodological approaches will be available to students of the new minor and the subject as an exemplar cross-community, cross-country case study in humanitarian engineering. More details about the study can be found at Schismenos et al. (2022a).

Conclusions

Humanitarian engineering education is crucial for disaster resilience and sustainable development strategies. Although many engineering students show interest in 'engineering for change' initiatives, their predominant focus on technical aspects risks marginalising socio-cultural knowledges, particularly when applied to community engagement and consultation. Students in social sciences and disaster management may have greater stakeholder engagement skills but lack applied technical engineering 'know-how'. In both scenarios, students do not always meet their industry needs as they lack inter-disciplinary education and training. Humanitarian engineering aims to address these as it teaches future professionals (engineers and social scientists) engaging in community resilience and development programs the humanitarian aspects of their role. This is not always an easy task and requires students to receive a holistic educational experience informed by a range of discipline perspectives.

This curriculum development addresses a known problem - it provides inter-disciplinary education and new discipline groups getting access to humanitarian engineering. It is expected to benefit both students and academics and teach inter-disciplinary awareness and practice to all engaging stakeholders including academics, students, industry and community partners. In the future, this initiative could lead to the development of other programs at Western (e.g. Major or Bachelor) co-developed with industry partners and other universities.

References

Arshad-Ayaz, A., Naseem, M. A., & Mohamad, D. (2020). Engineering and humanitarian intervention: learning from failure. *Journal of International Humanitarian Action*, 5(1), 1-14. https://doi.org/10.1186/s41018-020-00073-5

Colglazier, W. (2015). Sustainable development agenda: 2030. *Science*, 349(6252), 1048-1050. https://doi.org/10.1126/science.aad2333

Engineers Australia. (2022a). Women in engineering: Identifying avenues for increasing female participation in engineering, by understanding the motivators and barriers around entry and

progression. Retrieved https://www.engineersaustralia.org.au/sites/default/files/women-in-engineering-report-june-2022.pdf

Engineers Australia. (2022b). Pathway to the Future. Retrieved https://www.engineersaustralia.org.au/news-and-media/2022/07/pathway-future

Engineering for Change. (2019a). State of engineering for global development: Australia and New Zealand. Retrieved https://www.engineeringforchange.org/wp-content/uploads/2020/04/State-of-EGD-Aus_NZ-Full-Report.Updated3.2020.pdf

Engineering for Change. (2019b). State of engineering for global development: United States and Canada. Retrieved https://www.engineeringforchange.org/wp-content/uploads/2020/02/State-of-EGD-North-America-Full-Report_updated2.2020.pdf

Evis, L. H. (2022). A critical appraisal of interdisciplinary research and education in British Higher Education Institutions: A path forward? *Arts and Humanities in Higher Education*, 21(2), pp. 119–138. https://doi.org/10.1177/14740222211026251

Lucena, J., Schneider, J., & Leydens, J. A. (2010). Beyond Engineers and Community: A Path Forward. In *Engineering and Sustainable Community Development* (pp. 204-211). Springer, Cham. ISBN: 978-3-031-79961-7.

Pearson, L., & Pelling, M. (2015). The UN Sendai framework for disaster risk reduction 2015–2030: Negotiation process and prospects for science and practice. *Journal of Extreme Events*, 2(01), 1571001. https://doi.org/10.1142/S2345737615710013

Ramiah, R., Godinho, L., and Wilson C. (2022). Tertiary STEM for All: Enabling Student Success Through Teaching for Equity, Diversity and Inclusion in STEM. *International Journal of Innovation in Science and Mathematics Education.* 30(3), pp. 32-45.

Sardyga, A. (2020). Western Sydney University launches program for aspiring Indigenous engineers. Retrieved https://www.westernsydney.edu.au/newscentre/news_centre/story_archive/2020/western_sydney_university_launches_program_for_aspiring_indigenous_engineers

Schismenos, S., Stevens, G. J., Georgeou, N., Emmanouloudis, D., Shrestha, S., Thapa, B. S., & Gurung, S. (2022a). Flood and Renewable Energy Humanitarian Engineering Research: Lessons from Aggitis, Greece and Dhuskun, Nepal. *Geosciences*, 12(2), 71. https://doi.org/10.3390/geosciences12020071

Schismenos, S., Stevens, G., Emmanouloudis, D., Georgeou, N., Shrestha, S., Katopodes, N., & Wali, N. (2022b). Humanitarian engineering for renewable energy and flood early warning in remote communities: A scoping review of enabling factors and sustainability. *Journal of Sustainable Development of Energy, Water and Environment Systems*, 10(3), 1-27. https://doi.org/10.13044/j.sdewes.d9.0406

School Of Engineering, Design and Built Environment. (2020). Indigenous Strategy 2020 – 2025. Retrieved https://www.westernsydney.edu.au/__data/assets/pdf_file/0006/1869540/EDBE0375_Strategy_Plan_2021.pdf

Turner, R., Cotton, D., Morrison, D., & Kneale, P. (2022). Embedding interdisciplinary learning into the first-year undergraduate curriculum: drivers and barriers in a cross-institutional enhancement project. *Teaching in Higher Education*. https://doi.org/10.1080/13562517.2022.2056834

VanderSteen, J. D. J., Hall, K. R., & Baillie, C. A. (2010). Humanitarian engineering placements in our own communities. *European Journal of Engineering Education*, 35(2), 215-223. https://doi.org/10.1080/03043790903536869

Western Sydney University (n.d.-a). Sustaining Success: 2021-2016 Strategic Plan. Retrieved https://www.westernsydney.edu.au/__data/assets/pdf_file/0005/1819895/OVCH_5133_Sustaining_Success_2021-2026-_Booklet_web_AC.pdf

Western Sydney University (n.d.-b). Western Sydney University named world's best for sustainable development. Retrieved https://www.westernsydney.edu.au/newscentre/news_centre/feature_story/western_sydney_university_named_worlds_best_for_sustainable_development#:~:text=The%20University%20placed%201st%20overall,%2C%20research%2C%20outreach%20and%20stewardship.

Wilson, T. G., Breid, D., Christy, A. D., & Belloni, C. (2020, June). The Effect of Humanitarian Engineering on Female Learning and Confidence. In *2020 ASEE Virtual Annual Conference Content Access*.

Acknowledgements

This project was supported by the Western Sydney University Strategic Initiative Fund (SIF) as a cross-school project to develop inter-disciplinary curricular in the emerging field of Humanitarian Engineering.

Copyright statement