

A National Sustainability Challenge: Lessons in the development of Sustainable Engineering Education in Australia

Michele Rosano^a and Roger Hadgraft^b

Sustainable Engineering Group, Curtin University^a, University of Technology Sydney^b
Corresponding Author Email: m.rosano@curtin.edu.au

CONTEXT

This paper describes the evolution of a National Sustainability Challenge to assist in the development of an increased focus on sustainable education in engineering curricula.

PURPOSE

The journey starts with the development of the Sustainable Engineering Education Network (SEEN) which brought together senior academics and industry across Australia to review a 'state of the nation' position on sustainable engineering education in Australia and to propose a roadmap for future development.

APPROACH

The journey included a number of workshops focussing on the development of this roadmap and the initiation of a multi-disciplinary National Sustainability Challenge (the Challenge) to help promote the strategic value of sustainable engineering education in Australia.

RESULTS

A summary of the key outcomes from previous workshops is presented together with a proposed National Sustainability Challenge pilot for 2017, supported by the Australian Council of Engineering deans.

CONCLUSIONS

There is continuing involvement from a number of universities to ensure the successful implementation of the pilot in 2017 – Curtin, UTS, RMIT, Melbourne, ANU, with several others expressing an interest: UQ, USQ, CQU. EWB is currently preparing a proposal for how this Sustainability Challenge can be developed and staged for 2018. These details will be available at the conference.

KEYWORDS

Sustainability, curriculum change, ACED.

Introduction

Feedback from university academics and lecturers from workshops held at the Australasian Association for Engineering Education (A2E2) conferences since 2011 have acknowledged the increasing need to review sustainable engineering content and pedagogy in our engineering programs. As a result of this ongoing and facilitated dialogue, a Sustainable Engineering Education Network (SEEN) was established in 2013 to help promote the teaching of sustainable engineering education. SEEN included some 50 academics across Australia.

The ability to include more core sustainable engineering competencies, skills and sustainability related knowledge in already busy engineering degrees has been a major challenge in Australia for many years (M. Rosano & Biswas, 2015) and strategies have been developed to take an add-on approach or a redesign approach (Kolmos, Hadgraft, & Holgaard, 2015).

There is a pressing need for universities to prepare their graduates for a world where sustainability issues dominate the international agenda (Huisingh, 2010; Karatzoglou, 2012; Lozano & Young, 2012; Stephens, Hernandez, Román, Graham, & Scholz, 2008).

As educators, we need to engage graduates in solving 'wicked' sustainability problems. With increasing pressures of climate change, environmental impact, resource scarcity, climate change risk management and triple bottom line reporting requirements, engineering graduates are increasingly being challenged to demonstrate a skill set that meets the challenges of a changing world. The question remains: are students developing these skills in their current engineering education?

Engineering graduates face an increasingly complex array of sustainability issues including declining resource levels, rising water and energy prices, increasing demand for renewable energy, climate change induced risk management, human population growth pressures and green design challenges (National Academy of Engineering, 2007).

Challenges on the road to Damascus...

Feedback from university academics and lecturers from workshops held at the Australian Association for Engineering Education conferences in December 2011 (Perth) and December 2012 (Melbourne) confirmed a need to review sustainable engineering content and pedagogy in Australia. The 2012 workshop suggested the development of a sustainable engineering education network (SEEN) to support the shift towards a more multi-disciplinary and complex systems based approach to engineering education.

In June 2013, a symposium was held at University Technology Sydney to address the challenge of increasing sustainable engineering education in Australian universities as well as the establishment of a formal network to help promote it. The network was seen as a potential unifying structure and a necessary vehicle to achieve the education outcomes sought, including resource and information dissemination, capacity building and professional development in sustainable engineering.

Funding was received from the Federal Government Department of Resources, Energy and Tourism (RET) to hold the event so that interested academics could attend free of charge apart from individual travels costs to Sydney. RET sponsored the event in order to assist with the development of a proposed roadmap and the building of a community of practice around sustainability and energy efficiency education in Australia. More than 40 academics from across Australia attended the symposium, together with several industry representatives.

The focus of the inaugural symposium was on the development of a roadmap for action that could be used to both raise the profile of sustainable engineering education in Australia and to develop the academic and industry leadership needed to help support sustainable

engineering curricula in Australia. The main outcomes from this workshop recommended the development of a SEEN Network, increasing engagement with Engineers Australia and the development of a National Sustainability Challenge.

This symposium highlighted a number of challenges in the development of increased sustainable engineering education in Australia including:

- The lack of push from public policy in Australia toward sustainable energy/water/resource outcomes.
- Disciplinary arrogance in the overtly technical and discipline specific focus of current engineering degrees and Inertia in the university system for change in engineering education
- Sustainable engineering education and practice typically focused on 'fit for purpose' rather than 'fit for the future'.
- Engineering practice and education being treated as separate entities... Industry thinks universities are teaching sustainable engineering education and universities feel that if sustainable engineering practice is required, industry will let them know.
- Few engineering academics having actually practised as engineers.
- Separation of both engineering disciplines and natural sciences, but collective intelligence is essential in critical problem solving.
- Little interest by the engineering profession in influencing sustainability policy.

In addition, a number of education content and pedagogy challenges were also highlighted:

- What are the best methods for embedding sustainability in engineering education (curriculum design, unit based approach, inculcating across the entire degree, EA accreditation focus)
- Does the education provided by Engineering Schools across Australia match the skills required by industry and the sustainability challenges ahead?
- How do we embed systems thinking perspectives in the BEng?
- Sustainability management will require 'productivity step changes' not incremental 'efficiency gains'. What does this mean for our BEng education?
- How can we incorporate more multi-disciplinary and inter-disciplinary education in the BEng to help with the development of complex sustainability solutions?
- How to increase engineering leadership in sustainability management profession to influence sustainability policy?

Potential ideas to solve these issues were discussed during the SEEN workshops held at the Australian Association of Engineering Education Conferences held in 2013 (King, Hadgraft, & Rosano, 2013) and 2014 (M. Rosano, Hadgraft, & King, 2014) which recommended (Michele Rosano & Hadgraft, 2015):

- The further development of a community of practice in sustainable engineering education
- Working with Engineers Australia to develop a new 'practice note' on sustainable engineering
- Re-establishment of the Engineers Australia Education Committee
- A program to work more closely with the Australian Council of Engineering Deans
- The development of a National Sustainability Challenge to both promote the need for sustainable engineering education as well as the promotion of sustainable engineering practice in Australia.

Community of Practice in sustainable engineering education in Australia

The absence of a community of practice in Australia around sustainable engineering education was seen as a significant omission in the promotion and adoption of sustainable engineering education content and application.

SEEN was established in order to encourage collaboration between academics and industry representatives across key engineering disciplinary fields to support discussion, engagement and resource sharing in sustainable engineering education in Australian engineering schools. This support could include sustainable engineering teaching, resource dissemination, capacity building, and professional development. It was hoped that the network could also promote the case for, and benefits of, including SE content in engineering courses, and assist in the development and implementation of strategies to enhance university interest and activity in the area of sustainable engineering education.

In addition, a stronger community of practice could potentially provide members with an opportunity to present themselves as a unified national body of academics to influence university senior management and leadership on the value and need for sustainability education.

The higher education sector in Australia is self-managing; universities are autonomous and often work in isolation, with no Government direction on curricula development and only limited broad guidelines provided by Engineers Australia as the overarching professional body. This has often resulted in the onus being on industry and its representatives to demonstrate the demand for specific training needs and relay this to engineering schools.

In general, engineering degrees across Australia are largely devoid of sustainability management focus and content, with a primary emphasis on technical skill development (ref??)

Engineers Australia

Engineers Australia (EA) is the peak professional body and a national forum for the governing and advancement of engineering in Australia. EA is responsible for accrediting engineers and engineering programs and is a signatory to the [Washington Accord](#), the [Sydney Accord](#) and the [Dublin Accord](#).

The EA Code of Ethics defines the values and principles that shape decisions in engineering practice and provides a framework for members of Engineers Australia to use when exercising their judgment in the practice of engineering (Engineers Australia, 2010). These ethics require an engineer to: 1. Demonstrate integrity, 2. Practise competently, 3. Exercise leadership and 4. Promote sustainability.

Discussion at SEEN workshops has provided a number of suggestions regarding EA's role in the potential development of the sustainable engineering education agenda, including:

- The development of an Engineer Australia practice note on 'sustainability for engineers', building on the Sustainability Charter (Engineers Australia, 2007)
- The re-establishment of an Engineers Australia Education committee
- A formal review of how the EA competencies link with the sustainability skills required.
- How can EA as a professional body influence sustainability public policy and take up a leadership role in this area?
- How might EA and its accreditation process assist in the development of an agreed overall framework for shared terminology and content across sustainable engineering education.

The EA Code of ethics and guidelines on professional conduct broadly discuss the need for promoting sustainability and balancing the needs of the present with the needs of future generations. However, both the accreditation process and potentially the re-establishment of the Education committee could provide an opportunity to encourage more focus on sustainable engineering education and provide useful benchmarks for setting the minimum standards for sustainable engineering education content in the Bachelor of Engineering degree.

Universities/Schools of Engineering

SEEN discussion has also reviewed the role of academic leadership in sustainability education in Australian universities, with a particular focus on academic senior executive. The question of how to encourage universities to reflect on the important challenge of educating sustainability management leaders of the future was a constant.

Further discussion points included:

1. The need to establish a benchmark of sustainable engineering practice in Australian and international universities.
2. The question of how to get rid of the inertia in the university system for change in engineering education.
3. How to influence the Federal government's Excellence in Research Australia (ERA) Field of Research (FOR) rating systems which govern research evaluation and assessment. Currently there is no FOR for Sustainable Engineering research. It is commonly evaluated under alternative FORs including 'Environmental Engineering' or other discipline specific codes with no reference to sustainability or allowance for trans-disciplinary research.
4. Building capacity in Engineering Schools for sustainable engineering education.

A National Sustainability Challenge

The idea of the National Sustainability Challenge, based on the successful program developed by (Engineers Without Borders, 2015), was raised as an opportunity to leverage both student interest in sustainable engineering practice and staff training and development in this area.

The Challenge was to be initially presented as a fourth year capstone project competition to provide students with an important opportunity to further their understanding and problem solving skills in sustainable engineering application. In addition, their supervisors would also be engaged in providing critical thinking development around sustainable engineering concepts. Initial focus was on energy and water efficiency as the primary Challenge categories.

After discussion at a SEEN workshop in Melbourne, March 2016, it was decided to broaden the scope of the Challenge to include other disciplines and a much broader array of potential Challenge topics. We drew inspiration from a range of other awards, both nationally and internationally (ACTS, 2016; Aust. Government: DIRD, 2016; Renew Economy, 2016; Rockefeller Foundation, 2016; "Zahed Future Energy Prize," 2015).

The potential topics are still being confirmed but could include:

- Renewable/alternative energy
- Sustainable waste management
- Sustainable regional development
- Sustainable manufacturing
- Sustainable agriculture.

In terms of the Challenge format, it will be open at Tertiary level to all disciplines across all years. The project submitted must be multi-disciplinary and provide a solution to a problem within the Challenge category entered. Formal submissions are expected to be no more than ten A4 pages with a 3 minute supporting video outlining the sustainability problem being addressed and the potential solution offered.

EWB is currently engaged in the development of the administrative framework for the Challenge and in the development of funding partnerships with industry and government. Prizes will be awarded both at a State and National level for each Challenge category. A judging panel of eminent Australians involved in sustainability leadership will also be

developed. It is expected that Engineers Australia will also be closely involved with the development and promotion of the Challenge.

A small trial is being conducted in 2016 at RMIT, with results to be presented at the conference. A larger trial will be planned for 2017 at RMIT, UTS, the University of Melbourne and Curtin University before its potential national roll out in 2018.

While funding is still being sought for the Challenge, it is hoped that both university, industry and government financial support will be available.

Conclusions

In recent years, a number of workshops have been held to promote the value and need for sustainable engineering education. In 2013, concerned academics formed the Sustainable Engineering Education Network (SEEN).

The workshops and symposium held by SEEN over the past several years have focused on the development of a roadmap for the promotion and extension of sustainable engineering education in Australia. This paper has highlighted a number of challenges faced by sustainable engineering educators in Australia. In addition, it has discussed many of the missing links in supporting sustainable engineering education development and has suggested recourse to include the development of a strong community of practice for sustainable engineering academics, an extended role for Engineers Australia, the role of university senior management in promoting the need for sustainability education and the potential value of a national sustainability competition to promote the importance of sustainable engineering education and its value to society. .

The discussion at SEEN forums highlighted the concern many academics have that modern engineering degrees were not delivering a degree with broad intellectual understanding of sustainability or the required technical skills to meet the sustainability challenges presented by ongoing climate change, resource scarcity and environmental degradation pressures.

A National Sustainability Challenge could provide an education program that will allow tertiary students to increase their knowledge of the sustainability challenges ahead, to spend significant project time in considering and developing potential sustainability solutions and to become more cognizant of the sustainability challenges that will need to be managed in the 21st century. Hopefully, another journey of conversion.

References

- ACTS. (2016). Australasian Campuses Towards Sustainability - Green Gown Awards 2016. Retrieved 14 Sep 2016, from <http://www.acts.asn.au/initiatives/ggaa/2016ggaa/>
- Aust. Government: DIRD. (2016). Innovation to Create More Liveable Australian Cities. Retrieved 14 Sep 2016, from http://regional.gov.au/local/awards/2016/factsheet_innovation.aspx
- Engineers Australia. (2007). Sustainability Charter. Retrieved 14 Sep 2016, from https://www.engineersaustralia.org.au/sites/default/files/shado/Representation/Policy_Statements/policy_statement_-_engineers_australia_sustainability_charter_aug_2007.pdf
- Engineers Australia. (2010). Our Code of Ethics. Retrieved 14 Sep 2016, from <https://www.engineersaustralia.org.au/sites/default/files/shado/About/Us/Overview/Governance/codeofethics2010.pdf>
- Engineers Without Borders. (2015). EWB Challenge. Retrieved 23 Nov 2015, from <http://www.ewbchallenge.org/>
- Huisingsh, D. (2010). *The Roles, Opportunities and Obligations of Institutions of Higher Education for Promoting Sustainable Life-styles: How will we partner to help to make this become a reality.*
- Karatzoglou, B. (2012). An in-depth literature review of the evolving roles and contributions of universities to Education for Sustainable Development. *Journal of Cleaner Production.*

- King, R., Hadgraft, R., & Rosano, M. (2013). *Workshop 1B: Sustainability content in Engineering Degrees*. Paper presented at the Australasian Association for Engineering Education Annual Conference.
- Kolmos, A., Hadgraft, R. G., & Holgaard, J. E. (2015). Response strategies for curriculum change in engineering. *International Journal of Technology and Design Education*.
- Lozano, R., & Young, W. (2012). Assessing sustainability in university curricula: exploring the influence of student numbers and course credits. *Journal of Cleaner Production*.
- National Academy of Engineering. (2007). Grand Challenges for Engineering. Retrieved 06 Oct 2008, from <http://www.engineeringchallenges.org/>
- Renew Economy. (2016). SA offers \$250,000 prize to fast-track Adelaide zero carbon plans. Retrieved 14 Sep 2016, from <http://reneweconomy.com.au/2016/sa-offers-250000-prize-to-fast-track-adelaide-zero-carbon-plans-50716>
- Rockefeller Foundation. (2016). City Resilience Framework. Retrieved 14 Sep 2016, from <https://www.rockefellerfoundation.org/report/city-resilience-framework/>
- Rosano, M., & Biswas, W. K. (2015). De-constructing the sustainability challenge for engineering education: an industrial ecology approach. *Progress in Industrial Ecology: an international journal*, 9(1), 82-95.
- Rosano, M., & Hadgraft, R. (2015). *A National Sustainable Engineering Challenge: Improving engineering curricula across Australia*. Paper presented at the Australasian Association for Engineering Education Annual Conference.
- Rosano, M., Hadgraft, R., & King, R. (2014). *Workshop 1A: Solving wicked sustainability problems: What specific knowledge and skills do students need to have to solve modern sustainability issues and those of the future?* Paper presented at the Australasian Association for Engineering Education Annual Conference.
- Stephens, J. C., Hernandez, M. E., Román, M., Graham, A. C., & Scholz, R. W. (2008). Higher education as a change agent for sustainability in different cultures and contexts. *International Journal of Sustainability in Higher Education*, 9(3), 317-338.
- Zahed Future Energy Prize. (2015). Retrieved 14 Sep 2016, from <http://www.zayedfutureenergyprize.com/en/>

Acknowledgements

The authors acknowledge the financial support from the Australian Council of Engineering Deans to move this project forward during 2016.