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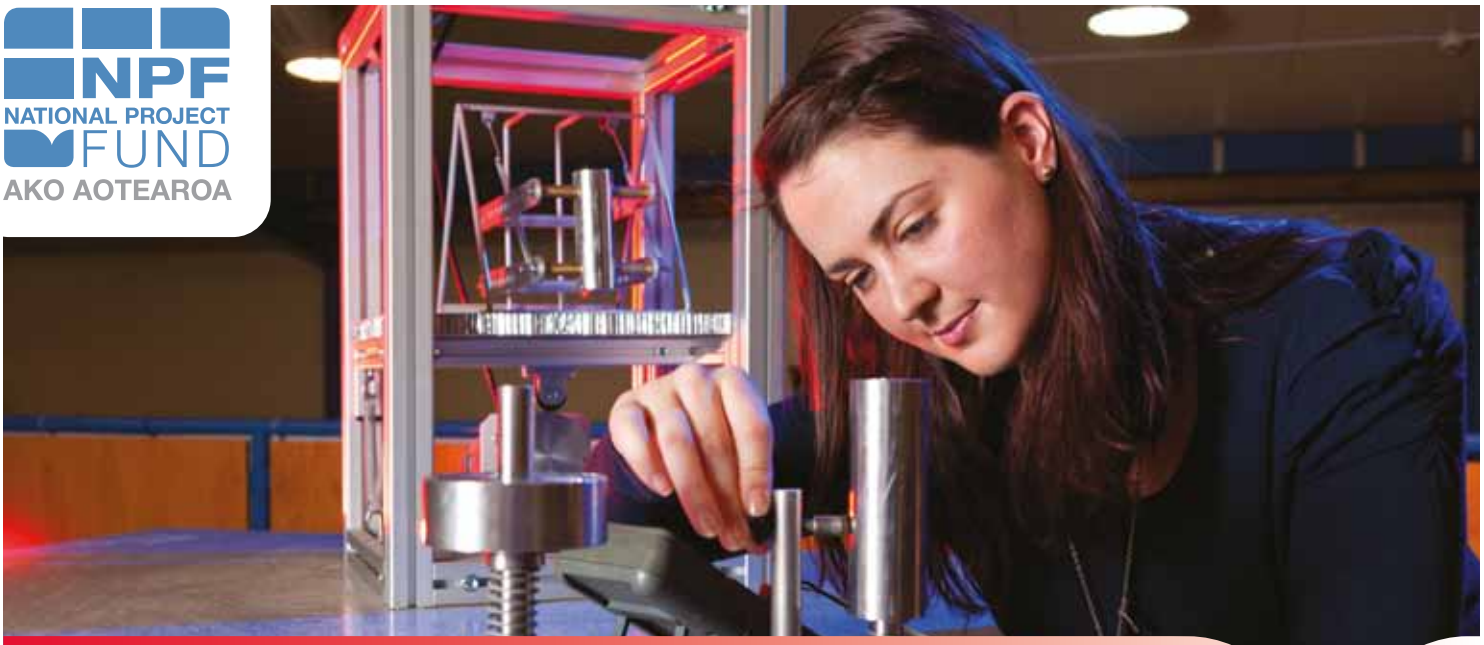

Research Report

Sustained improvements in teaching and learning in engineering education

Janis Swan and Elizabeth Godfrey, University of Waikato

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

AKO AOTEAROA
NATIONAL CENTRE FOR TERTIARY TEACHING EXCELLENCE

Title: Sustained improvements in teaching and learning in engineering education

Authors: Janis Swan and Elizabeth Godfrey, *University of Waikato*

Project team:

Professor Janis Swan, *University of Waikato;* Dr Elizabeth Godfrey, *University of Waikato;* Dr Gerard Rowe, *University of Auckland;* Dr Rob Torrens, *University of Waikato;* Neel Pandey, *Manukau Institute of Technology;* John Findlay, *Otago Polytechnic*

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PO Box 756

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Executive summary

The aim of this project was to bring together engineering education leaders from New Zealand engineering degree-granting institutions to scope and develop a strategy to support sustained improvements in engineering teaching and learning. The engineering education community was keen to share research and best practice experiences of curriculum design, delivery, student assessment, evaluation, quality control and teaching resources. Project activities aiming to strengthen this community included a national Engineering Education Leaders forum highlighting current New Zealand issues and research projects, a workshop considering the potential for threshold concepts as a tool for curriculum renewal, relationship-building meetings with academics at individual institutions, collating a community database of self-identified academics, and establishing an accessible web-based repository for information dissemination of recent and current New Zealand-based engineering education research, projects and funding sources.

The first project outcome was identifying that there was a community of over 80 academics. The project activities and resulting networking stimulated and contributed to a wide range of current investigations, innovative pedagogical interventions and opportunities for inter-institutional collaboration, which will undoubtedly optimise the quality of teaching and learning offered in our institutions.

The second outcome was the development of a proactive support strategy and recommendations to sustain and optimise the quality of teaching and learning in engineering degree programmes in New Zealand. This strategy includes holding an annual forum of engineering education leaders and researchers, which would allow face-to-face sharing of experience and best practice, help establish personal connections, and maintain regular but not invasive (predominantly virtual) engagement with the community. These activities would enable dissemination of information, research, conference opportunities, and access to project funding.

Despite identifying challenges offered by the current higher education environment, opportunities to provide a way forward and implement this strategy are suggested. Leadership and support within engineering institutions will be essential but with the aid of partners such as the Australasian Association for Engineering Education (AAEE), Ako Aotearoa and the Institution of Professional Engineers New Zealand (IPENZ) a strong community of practice will ensure that engineering education in New Zealand aims for and maintains excellence in teaching and learning outcomes.

Background

Most New Zealand tertiary engineering educators want to deliver quality teaching (despite scarce resources) and take pride in the learning achievements of their students. Although engineering education in New Zealand has had its champions, innovation and research in New Zealand engineering education has not had a cohesive direction. Projects have been led by enthusiastic academics at individual institutions, largely without funding. In many instances, these academics and/or their research projects are unknown outside their 'home' institution. The excellence of some of these individual initiatives has been recognised by six Australasian Association for Engineering Education (AAEE) Excellence Awards for "Individual Teaching Excellence" and "Programs that Enhance Student Learning" since 2005. Other engineering educators' efforts have been recognised by receiving teaching awards from their institutions. However, the potential of engineering education research continues to be undervalued. In particular, enthusiastic and competent engineering education champions believe the current culture is lacking in respect and support for the pursuit of scholarly investigations in student learning, assessment and evaluation of innovations that pertain to engineering.

A strong community of engineering academics in Australia and New Zealand with an interest in the scholarship of teaching and learning in engineering education has existed since 1989 under the umbrella of the AAEE. The Association is financially supported by the Australian Council of Deans, individual New Zealand engineering departments/schools and Engineers Australia, which gives free membership to every engineering academic in the institutions offering four-year professional engineering degrees. The AAEE hold an annual conference, usually in an Australian city (although the 2006 conference was held in Auckland) and also delivers workshops (often subsidised) in various regional centres. Many members of the AAEE community have been recipients of Australian Learning and Teaching Council project grants (now the Office of Learning and Teaching, OLT). These activities have improved the effectiveness of engineering education in Australia and fostered high-quality engineering education research.[1] To date, New Zealand engineering academics have had relatively low participation in AAEE activities. These academics are severely stretched by the competing demands of teaching loads, the need for a research profile (prioritised by the PBRF), and increased reporting requirements for professional accreditation of engineering programmes. The ability to continue delivering high-quality engineering education and innovate (for which New Zealand has been renowned) will benefit from a collaborative approach, facilitated by a strong community of practice. It is important that students and graduates are taught in an environment of best (and informed) practice.

Recent studies by the IPENZ[2] report that New Zealand needs more engineering graduates at all levels to enhance the country's economic performance. Demographic information in the National Engineering Education Project (NEEP) report indicates that the New Zealand student population will become more diverse and that a potentially less-well-prepared student cohort will challenge engineering educators, who will need to respond effectively via curricula development, assessment and teaching methods to optimise student recruitment, success and retention, particularly at first-year

[1] A list of sponsored projects and their final reports is provided in Appendix A.

[2] National Engineering Education Plan Project reports http://www.ipenz.org.nz/ipenz/Education_Career/NEEP.cfm

level. An engineering academic participating in a recent workshop organised by the UK Higher Education Academy Engineering Subject centre very articulately expressed this need:[3]

> *…if students are to benefit, we as a group need to be aware of best practice and the most appropriate methods of delivery. For this to become a reality we must have at least a working knowledge of current pedagogical opinion and be able to draw upon the innovation of our colleagues and peers.*

International exemplars of cross-institutionally funded projects from Australia (Office of Teaching and Learning, OLT[4]), UK (Higher Education Academy Engineering Subject Centre) and the USA (NAE and NSF) demonstrate how useful such projects can be in stimulating innovation and improvements to teaching and learning outcomes. Recent research on engineering education attributes, together with information on the New Zealand requirement for more engineers, which must be obtained from a more diverse population in terms of ethnicity and education, meant the project team for this Ako Aotearoa-funded project recognised that it is timely to have a more unified, national approach. Issues of common concern have been identified by groups of New Zealand engineering education leaders at meetings in 2009, and by the IPENZ-sponsored collaborative research and development National Engineering Education Plan (NEEP). The support of Ako Aotearoa has enabled this collaborative project to move the discussion to action.

Project aims

The aim of this collaborative project was to bring together engineering education leaders from New Zealand engineering degree-granting institutions to scope and develop a strategy to support sustained improvements in engineering teaching and learning.

The means to achieve this was by nurturing and growing an engineering education community that shared best practice experiences, supported by evidence and evaluation, of curriculum design, delivery, student assessment, evaluation, quality control and teaching resources. An immediate outcome of the project would be a means to access and disseminate findings from recent and current engineering education projects in the context of relevant global education developments. Most current New Zealand projects in engineering education were usually institution-specific with little if any support from external funding sources. A longer-term impact from this project was expected to be the development of projects to meet emerging needs in the New Zealand context by identifying potential areas of collaborative research and potential educational leaders and partners. These projects would target improved teaching practice and learning outcomes across tertiary engineering education.

[3] Arlett *et al*. (2009). Establishing and supporting education research in engineering from a local and national perspective. Research in Engineering Education Symposium, QLD. http://rees2009.pbworks.com/f/rees2009_submission_85.pdf
[4] Previously the Australian Learning and Teaching Council (ALTC).

Project activities

Under the auspices of this project, the following activities have been achieved:

Workshop. Engineering Thresholds: A tool for curriculum renewal – 25 June 2011 (held at the University of Auckland)

Prior discussions with members of the New Zealand engineering educators community identified that threshold concepts, a recent education categorisation, was potentially a pathway to engaging their colleagues with discussions around teaching and learning. Professor Caroline Baillie, of University of Western Australia, who currently leads an OLT-funded project on Threshold Concepts in Engineering, facilitated this workshop. Twenty-three participants from five institutions attended, and found the day informative and invigorating. Funding for Prof. Baillie was provided by the University of Auckland.

Engineering Education Leaders Forum – 29 August 2011 (held at Manukau Institute of Technology)

A priority list of topics for the forum, identified by surveying prospective attendees, was used as the basis for the day's programme. New Zealand engineering academics with recent or relevant expertise led discussion, often incorporating and sharing their own recent research. Dr Keith Willey of University of Technology Sydney, a prolific writer in the field and the recipient of numerous teaching awards, was the guest speaker on "Conversations about Learning – Collaborative Learning, Assessment and Feedback".

Every engineering degree-granting institution nominated representatives and 40 participants registered. One desired outcome of this forum was to identify collaborators and topics for future project proposals, so the attendance of the Ruth Peterson, the Ako Aotearoa Regional Hub Manager, was appreciated.

The participants used the afternoon sessions to identify topics for further investigation and collaborations. The following five topics, prioritised from a larger set, emerged:

- Threshold concepts and curriculum design in engineering, particularly first year.
- Gap analysis between NCEA and first-year engineering.
- Group and collaborative assessment.
- Barriers to engaging staff in learning and teaching, particularly active learning and Project based learning.
- Best practice teaching of professional ethics, professional responsibility and liability.

Further investigation on these topics is being actively pursued as funding opportunities arise (see page 7*ff*).

Community Database

A database of self-identified academics with a personal interest in being part of a community of practice in the scholarship of teaching and learning in engineering education has been collated. There are currently 81 academics from New Zealand tertiary engineering providers on this list.

Information Dissemination via a wiki site

A wiki site developed at http://nzeelcollaborativeproject.pbworks.com has been acting as an (interim) accessible repository for the following resources compiled as part of this project. It contains:

- a database of all engineering education-related peer-reviewed conference and journal papers, authored by New Zealand academics in the last five years (each author was restricted to only five references)
- a database of all internally and externally funded projects relating to engineering education from the last five years, including current incomplete projects
- a list of journals and conferences relevant to engineering education, known to be of high repute and incorporating double blind peer-reviewing processes (based on the 2010 Australian ERA listings).

A summary document of funding sources and application dates available in New Zealand is on hold pending recent developments.

A major challenge will be the maintenance and updating of these resources.

Relationship building

During the 18 months of the project, the Project Officer has met with staff groups at seven degree-granting institutions (in several cases, more than once for follow-up sessions) with the aim of sharing information, raising issues and identifying potential research projects both internal and collaborative across institutions. Discussion has been continued by means of phone and email correspondence. The Project Officer's role was seen as an important link in connecting potential collaborators. Funding a position of this type is seen as crucial to sustaining these relationships. The tight time and economic constraints of the current higher education environment require academics to prioritise their time and effort to personal and their local institution's needs.

Current engagement in engineering education projects

Despite the dearth of opportunities for external funding for engineering education projects and research, an informal survey in June 2012 elicited the following list of activities, which demonstrates the energy and enthusiasm of the community. Most of these were stimulated by discussions and follow-up activities amongst the community built under the auspices of this Ako Aotearoa project.

- **University of Waikato** has set up the Engineering Education Research Unit (http://www.waikato.ac.nz/eeru) with the support of the Wilf Malcolm Research Institute (http://www.waikato.ac.nz/wmier/).
- **University of Auckland** has used a systems engineering approach to drive a major rethink of how students develop professional skills. This has resulted in innovative curriculum redesign of the professional development strand across all four years of the engineering degree programme with a strong focus on Systems Engineering and building experience of working in large (up to 25 member) interdisciplinary teams.
- **University of Auckland** ran a workshop in April 2012 on "Peer Assisted Study Sessions – PASS" with a speaker/facilitator from the University of Wollongong. All the regional institutions were invited to attend.
- **University of Auckland** and **University of Canterbury's** departments of Chemical Engineering are coming to the end of a TEC-funded project on Virtual Plants.

- **University of Canterbury's** Associate Professor Ken Morison of Chemical and Process Engineering led the UoC's involvement in 2011 in a multi-institution, Australian-funded project on curriculum renewal that used the "Engineers without Borders Challenge" project.
- **University of Canterbury's** Associate Professor Morison obtained a small internal teaching development grant in 2012 for the project "Threshold concepts in modelling dynamic engineering systems".
- **University of Canterbury's** Professor Tanja Mitrovic continued research on an intelligent tutoring system, applying it various engineering areas. Her team has received funding from UoC to develop the "UCanAsk system", which allows lecturers to ask questions (multi-choice, short-answer or image-based), receive feedback from students via mobile devices, and produce summaries. The system has already been used in courses in 2012.
- **University of Waikato** and **University of Auckland** are building on UoA's experience in diagnostic or competency assessment of incoming students. The UoW carried out a pilot assessment of their incoming engineering cohort to identify remedial teaching needs. UoC and Victoria University of Wellington (VUW) have expressed interest in a national project.
- **Victoria University of Wellington's** Professor Dale Carnegie, using the findings from his TEC-funded project on "Engagement and Retention of students in Electronic Engineering", is developing one of the themes identified at the August 2011 forum as a project "Understanding teaching and learning communities in secondary school education and tertiary engineering education". Unfortunately, the initial TLRI application was not successful but other funding sources are being investigated.
- **Waikato Institute of Technology (Wintec)** is investigating a collaborative project "Capstone Projects in the three-year Bachelor of Engineering Technology". Unitec is a potential collaborator but the project is currently unfunded.
- **Unitec** has expressed the wish to work with other BEngTech and Diploma providers to investigate strategies to cope with the diversity in academic background of the students presenting themselves for these qualifications. Although most students have come through NCEA in high schools, Unitec has particular concerns about the quality and lack of consistency from this modular qualification for students entering Diploma programmes from NCEA level 2.
- At **Massey University** a major restructure of curriculum of the undergraduate degree is being implemented from 2012. The key challenge is seen as not 'what we teach' but 'how we teach'. Massey has supported the review with both funding and the input of teaching and learning support staff but the challenge is balancing the day-to-day activities with developing new initiatives and completely new ways of teaching, new ways of engaging with students, and new technologies. It is recognised that rigorous evaluation of the learning outcomes from the new curriculum is unlikely amidst competing pressures.

Note: The University of Waikato (UoW) has been awarded a Teaching and Learning Research Initiative Grant for "Re-envisioning tertiary teaching and learning of difficult concepts: How 'threshold concepts' afford understanding of problematic ideas". One aspect of this project is threshold concepts in electronics. Whilst this project was not a consequence of the current project, and encompasses disciplines other than engineering, Professor Jonathan Scott of UoW has built on the contacts made at the workshop and forum organised by this Ako Aotearoa project to identify collaborators at the University of Auckland, Manukau Institute of Technology and Victoria University of Wellington to contribute a broader spectrum of data.

Project outcomes

Project outcomes are described in terms of the dual aims of establishing a community of practice (that is, a New Zealand Engineering Education Leaders (NZEEL) network) and scoping and developing features of a discipline support strategy.

Establishing a community of practice

A community of over 80 members with representatives from each of the 13 engineering degree-granting institutions has been identified. The contact list now existing has already been used by members of the community to promote workshops across institutions and to publicise engineering education-specific conferences.

Feedback from participants clearly indicates that the activities arising from this project have stimulated a sense of community:

> *The impetus created by this Ako Aotearoa project has been [a] tremendous help to initiating discussions on engineering education research. We have been able to access international visitors for workshops and also create an opportunity for people to network. Often these people did not know others w[ere] thinking of researching in the field and/or it has created the opportunity for collaborative research or even the impetus to start small projects.*
>
> *In particular it was good to meet with fellow engineers who are interested in education. I would like to see it repeated as I haven't engaged with anyone (other than ...) since that event. I feel it needs an event to 'force' people to engage.*
>
> *It's essential that our discipline can attract the capable, but also once we have them, we keep them and get them to succeed. To do this we have to engage as a community to keep improving our teaching. Also, internationally this field is growing so we would be very short-sighted to not keep it going.*
>
> *The greatest impact for me was to meet people from other organisations who have similar interests and to give inspiration for trying some new teaching strategies.*
>
> *We found this conference extremely valuable. It was very helpful to hear the educational situation from other educational providers. We, the tertiary engineering education community, need this sort of thing so we can coordinate our efforts in helping students succeed in their learning.*

The network allows individual responses in the sector to present a unified and therefore more emphatic response to issues of the day. An example was the submission on alignment of NCEA standards made on behalf of the community. Without such a community it has been difficult, working in isolation, to align individual activities with national aims.

The website, which uses a readily accessible wiki form, has been made available to the community, providing easy updating. Rather than duplicate effort, the wiki site provides links to the AAEE-scholar website and its extensive range of resources. The wiki site was always viewed as an exploratory, temporary repository to enable information sharing. The intention at the close of the project is to transfer this wiki to a stable and maintained website as soon as a host institution is identified. As indicated earlier, consideration of the maintenance and updating of this website will be required. It was also noted by the community that a website alone does not guarantee the sharing of information

with a time-poor community, and they would prefer a brief headlining notification system of updates, such as the American Society for Engineering Education's "first bell" emails.

The Engineering Education Leaders Forum, held in August 2011 with approximately 40 participants, enabled the results of projects conducted at individual institutions to be shared more widely. A pleasing outcome was that participants reported that they were able to implement activities demonstrating evidence-based practice that were discussed at the forum. As indicated above, several participants have initiated investigative projects at their own institution. Prior to the forum, there was no location or opportunity for those with responsibility or enthusiasm to connect with each other except via *ad hoc* or personal networks. Comments from participants affirm the value seen in an event such as the forum:

> *In particular, engineering lecturers need access to relevant pedagogy and new initiatives to encourage better teaching as technologies rapidly change. An annual conference would be of great benefit.*
>
> *It seems to me that an annual meeting to share experiences, the new ways of delivery and assessment to try and collectively keep up with rapidly changing trends in education delivery will be essential for the future.*

Feedback from members of the community obtained via an emailed questionnaire suggested that formalising the network with the Engineering Deans, and identifying a person (or persons) who could act as a national "champion" or "driver" is needed to provide ongoing liaison and support, to sustain the network. A sponsor or funding source for this role is not immediately apparent. The current higher education environment has a strong focus on research outcomes, and prioritises technical research and its associated external funding. This focus, combined with heavy workloads for all academics, compounded by tight budgetary constraints, left many in the community apprehensive about their ability to prioritise scholarly approaches to their teaching.

IPENZ, which provides professional accreditation for both the four- and three-year engineering degrees by setting and approving the achievement of appropriate engineering graduate attributes, has indicated that it believes the NZEEL network provides a valuable tool in disseminating and sharing best practice. IPENZ sees particular value in sharing of experience, across institutions, of how institutions teach and engage students with the attainment of the desired professional skills. The focus of the accreditation process is on demonstrating continuous improvement processes. IPENZ indicated its willingness to be involved by attendance at the first forum, and offered to contribute to the workshops.

Scoping a discipline support strategy

The management team for this Ako Aotearoa scoping project suggests that the way forward is for a proactive discipline support strategy, which would include:

1. maintenance of regular but not invasive (predominantly virtual) engagement with the community – enabling dissemination of information, research, conference opportunities, project funding opportunities to:
    - provide a framework as a community for responding to issues of national interest related to engineering education

- provide a mechanism/community of practice that supports those academics who wish to pursue education-related investigative or research projects
- promote engineering education as a field of research with rigorous, internationally recognised credibility
- identify and support the presentation of cross-institutional workshops on topics of mutual interest

2. holding an annual forum of engineering education leaders. This would allow face-to-face sharing of experience, best practice and the establishment of personal connections.

Challenges to the implementation of the strategy

The two major challenges to the implementation of the strategy and the sustainability of a community of practice in engineering education are:

1. perceptions of a low profile and lack of prioritisation for scholarly approaches to engineering education
2. lack of funding and support for those academics wishing to pursue investigations or research in the area of engineering education.

The engineering education community of practice has been targeted at involving two categories of engineering academics, which may or may not be mutually exclusive:

1. those persons with responsibility for curriculum design and delivery, and issues of quality control, and
2. those academics with enthusiasm for engaging with the scholarship of teaching and learning – whether it be to better their own teaching or to engage in educational investigations and research.

All of these individuals operate in their own institutions under the auspices of an Executive Dean or Head of School.

The New Zealand Council of Engineering Deans (NZCED) is an informal network of Executive Deans from the four-year degree-granting institutions, with a Chair appointed biennially. This Council has no secretariat or financial base. Each institution makes a *per capita* financial contribution of $125 per 500 undergraduate students to the AAEE to enable academic staff to be members of AAEE at no cost to the individual.

Few, if any, of the institutions include funds in their School/Faculty budget for engineering education-related activities such as attending conferences, workshops or meetings. Most academics attending AAEE or international engineering education conferences are either self-funded or use funding from personal consultancy or project funding.

Feedback from academics in the community of engineering educators has reinforced the concern that nurturing and sustaining communication and relationships in this community will be challenging in the current higher education environment, which is enthusiasm-rich but time- and resource-poor. There is a common perception that time spent on the scholarship of teaching and learning is not valued as highly as technical research outputs. The community is not yet self-sustaining and the opportunity the current Ako Aotearoa project gave to fund a Project Officer, who has been able to connect potential collaborators, advise and disseminate relevant research and practice, and assist in preparing conference and journal papers as well as funding proposals, has been invaluable.

The activities currently underway at engineering institutions listed above show that almost no project has been able to source external funding, and all have been limited in their continuation by availability of internal funding and resources. It was unfortunate that the period of the project, for which the Project Officer's role was foreseen as strongly supporting project proposal writing, overlapped with an unpredicted lack of external funding. Restructuring of potential funding opportunities from Ako Aotearoa available from August 2012 will be useful, particularly where institutional support is available, for the sector to further explore the topics identified earlier. It is important that opportunities to fund the ongoing work of the Project Officer are explored.

Despite engineering academics in most instances putting an enormous effort into providing innovative and engaging curricula, along with the rhetoric of valuing teaching excellence, the fiscal environment within most schools of engineering does not allow funding for anything other than "business as usual", so funding for teaching and learning research is difficult to obtain. Engineering does not have a strong record in educational research or a tradition of including the scholarship pertaining to teaching and learning. Those academics wishing to investigate, research or evaluate processes of student learning and learning outcomes are unsupported both economically and professionally relative to academics engaging in technical, engineering science research. Examples lie in the lack of funding for conference attendance, and the lack of professional recognition for research publications in engineering education.

> *PBRF has both helped and hindered. There are now more teaching staff with an academic focus such that their whole career is likely to be as an academic so engineering education should be a priority. Also the linkage between practitioners and academic teaching staff is often at risk with PBRF drivers. With PBRF, the place of the practitioner (without research) contributing to engineering education is harder to support.* (Feedback from one Head of School)

One of the aims of this scoping project was to formalise the New Zealand Engineering Education Leaders network under the umbrella of the NZCED. A meeting of NZCED planned for May 2012 had been postponed twice. The outcomes and recommendations contained in this report were presented by Professor Janis Swan and Dr Gerard Rowe at the August 2012 meeting of NZCED. Discussion ensued around the proposed recommendations to sustain the network of those academics responsible for issues of curriculum design and delivery, and quality in teaching and learning outcomes. The deans recognised the benefits of this network in terms of optimising human and economic resources gained by inter-institutional collaboration. Informal support was expressed but no formal commitment was provided at that point in time.

Opportunities for the future

Several opportunities to provide a way forward and implement most if not all of the proposed opportunities will support the strategy of increased engagement.

Work even more closely with AAEE

During the life of this project, the AAEE has had a major initiative running, to identify an "AAEE Champion" at each of the Australian and New Zealand universities offering engineering degrees. The role of these champions is evolving, and the potential exists for the New Zealand champions to work together in a leadership role.

One example is the annual meeting of Australian Engineering Education leaders (usually the Associate Dean of Teaching and Learning or their equivalent), which usually occurs at the time of the AAEE annual conference. New Zealanders have been invited and some representation has been achieved at each meeting since 2008, but the context is predominantly targeted at Australian issues so the New Zealand participants have expressed the need for their own national event.

AAEE has funding (from ACED and NZCED levies) to subsidise a programme of workshops across Australasia. One workshop was held in 2009 and discussions have been initiated with IPENZ for a combined workshop to be presented in New Zealand, along the lines of a successful series organised in Australia based on curriculum alignment and graduate learning outcomes.

Hosting the Australasian conference in New Zealand raises the profile of engineering education scholarship and two institutions have worked together to put in a proposal to host the 2014 conference in New Zealand. IPENZ has been very positive in expressions of support and is prepared to underwrite the conference.

Work more closely with Ako Aotearoa

Ako Aotearoa recently announced its focus to "support educators and managers across the tertiary sector to enhance their and their organisation's teaching and learning practice". The initiative, which will include workshops, forums, seminars and other events such as conferences and symposia,[5] is welcomed.

The possibility of collaborating with Ako Aotearoa to provide events specifically targeting engineering educators will be a valued opportunity to sustain the activities started in this project. Funding for individuals wishing to attend these workshops may well be a constraint but this is seen as an excellent opportunity to advance professional development in teaching and learning practice.

Work with the support of the NZCED

The most desirable scenario would be for the NZCED to see the benefits of a strong Engineering Education Leadership network, and consider how they might support and fund this network. A first step to demonstrate this support will be the inclusion in faculty/school budgets for attendance at events targeting both research and professional development in teaching and learning.

Whichever opportunities can be developed, it seems clear that some source of external funding will be necessary. The dedicated attention of a project manager, or champion, who can provide a focus and

[5] http://akoaotearoa.ac.nz/events

dissemination point has been demonstrated. Without this focus, the competing demands are likely to lead to a lack of sustainability.

Recommendations

Based on the assumption that ensuring excellence in curriculum design and delivery of engineering degrees requires access to evidence-based best practice and research, those engineering academics with a responsibility for, and/or interest in, the scholarship of teaching and learning have a crucial role to play. A strong, supportive community of practice for these engineering education leaders committed to the improvement of teaching and learning will unquestionably have a substantial impact on their colleagues and on student learning. The follow recommendations are intended to support the sustainability of this community.

1. That an annual forum be held with a keynote speaker and New Zealand speakers providing updates on innovations, and best practice in curriculum design, delivery and assessment.
2. That each Engineering Dean commits to funding the AAEE Champion or Associate Dean Teaching and Learning equivalent to attend the AAEE conference and associated ADTL meeting each year.
3. That each Engineering Dean commits to allocating funding to support the attendance at the AAEE annual conference each year of those staff member(s) who have had a peer-reviewed paper accepted into the conference.
4. That the New Zealand Council of Engineering Deans, in conjunction with AAEE, IPENZ and Ako Aotearoa, consider sponsorship and/or funding of a person (or persons) to maintain the initiatives and resources emanating from this project.
5. That members of the engineering education community be encouraged to apply for Ako Aotearoa Good Practice publication funding, in order to disseminate exemplars of innovation in curriculum delivery and design.

Appendices B and C contain the recommendations provided in two very recent international reports on sustaining innovation and systemic change in engineering education. They provide useful exemplars of the seriousness with which these issues are being viewed in the UK and US.

Appendix A: Engineering projects funded by the OLT

Curriculum specification and support systems for engineering education that address revised qualification standards
Authors: Elizabeth Godfrey, Robin King (2011)
Lead Institution: University of Technology, Sydney.
Accessed 24 October 2012 at http://www.olt.gov.au/resources/1675?solrsort=score%20desc

Gender-inclusive curriculum in engineering and construction management
Authors: Julie Mills, Mary Ayre, Judith Gill (2012)
Lead Institution: University of South Australia.

Bridging the gap: Matching students and staff through discipline-based self-evaluation and co-creation of more appropriate pedagogies in engineering
Authors: Wageeh Boles, Roger Hadgraft, Prue Howard, Hilary Beck, Lesley Jolly (2009)
Lead Institution: Queensland University of Technology.
http://www.olt.gov.au/resources/1675?solrsort=score%20desc

Development, deployment and educational assessment of advanced immersive learning environments for process engineering
Authors: Ian Cameron, Caroline Crosthwaite, David Shallcross, John Kavanagh, Geoff Barton, Nicoleta Maynard, Moses Tade, Andrew Hoadley (2009)
Lead Institution: The University of Queensland.
Partner Institutions: CUT, Melbourne, Monash, Sydney.
Accessed 24 October 2012 at http://www.olt.gov.au/resources/1610?solrsort=sort_title%20asc

The engineering design journey: needs, concept and reality
Authors: David Shallcross, Nicoleta Maynard, Jo Dalvean (2011)
Lead Institution: The University of Melbourne.
Accessed 24 October 2012 at http://www.olt.gov.au/resources/1610?solrsort=sort_title%20asc

Engineering Thresholds: An Approach to Curriculum Renewal: Guide for Engineering Educators on Curriculum Renewal using Threshold Concepts
Author: Sally Male (2012)

An outcome report of the OLT project "Engineering thresholds: an approach to curriculum development"
http://www.ecm.uwa.edu.au/__data/assets/pdf_file/0018/2172501/Engineering-Thresholds-Guide-120828.pdf

Designing the Future
Authors: R. Goldsmith,C. Reidsema, D. Campbell, R. Hadgraft, D. Levy (2009)
Paper from the 20th Australasian Association for Engineering Education Conference, University of Adelaide, 6 to 9 December 2009.

Appendix B: Extract from *Achieving excellence in engineering education: the ingredients of successful change*

Dr Ruth Graham (March 2012)

Published by The Royal Academy of Engineering

A full copy of this report is available online at http://www.raeng.org.uk/change

This report was jointly funded by the Massachusetts Institute of Technology (MIT) and The Royal Academy of Engineering.

p. 64 Recommendations

For the engineering education community

The study has highlighted a number of barriers and facilitators of systemic educational change in engineering schools and departments across the world. On the basis of the study findings, the prevalence and success-rate of curriculum reform would be significantly improved by:

1. The development of a set of simple tools to measure effective teaching and learning in engineering. Such tools would serve two very important purposes:

    (i) to support the process of promotion and reward of faculty based on their educational contribution, and

    (ii) to provide an accepted template by which departments/school could monitor the impact of curriculum reforms without the need to develop their own bespoke models.

2. The ready availability of evidence on the impact of educational reform on programme performance. Given that the majority of successful reform efforts are triggered by a critical, largely market-driven, problem, evidence of the long-term impact of change endeavours in improving their market position would be of great benefit to others considering change. Such evidence could be in the form of a longitudinal study of a successful reform effort from a well-regarded institution, charting the impact of the change on factors such as recruitment, retention and employability, and comparing these with competitor institutions.

3. Funding to support educational change should be allocated, where possible, to whole departments with the explicit involvement of the Department Head, rather than to individuals or groups. Receipt of funding should also be contingent on a long-term impact analysis.

For engineering schools and departments

The study has identified a number of strategies and features associated with successful and sustainable change. On the basis of these findings, a number of specific recommendations have been made to support engineering schools and departments wishing to embark on widespread educational change.

Recommendations for departments/schools wishing to embark on systemic change, based on the study

PREPARATION

Collect evidence: gather quantitative evidence of the performance of your programme, as compared to competitor institutions, with a focus on key areas of concern to your current or future market position.

Engage the Head of Department: devote as much energy as possible to ensuring that the Department Head is actively supporting, and preferably leading, the change. If their support is limited, be aware that your chances of long-term success will be severely diminished.

Consult senior university management: open informal discussions with university management about plans for change. Identify potential conflicts and gauge levels of support.

PLANNING

Communicate need for reform to department-wide faculty: focus on the critical need for change, supported by the evidence gathered, and the potential impact of reform on faculty day-to-day activities. Avoid specifying details of *what* the change should look like. Underline university support for change, if this is in place.

Faculty-wide curriculum design: engage most, if not all, faculty in a department-wide educational design process. Encourage them to think outside their discipline, identify the fundamental educational priorities and design a coherent curriculum, where all new elements are carefully interlinked with existing courses. The new educational approach should be distinct and something that will put your institution 'on the map'. At least one portion of the curriculum should remain unchanged.

Consult external perspectives: ensure that some external voices are heard. Possibilities include an Industrial Advisory Board with real 'teeth', sending faculty to visit peer institutions that have implemented positive changes and/or appointing an educational/industrial advisor. Such activities are particularly important where there has been little recent faculty turnover and/or few faculty [members] have industry experience.

Appoint a management team and release their time: carefully select a management team of 2–3 individuals who are well-respected and understand the detailed operation of the undergraduate programmes. Formally release a portion of their time to devote to detailed planning and implementation.

Establish impact evaluation: select a method by which you can collect impact data throughout and beyond the change process and collect 'base-line' data relating to the period prior to reform.

IMPLEMENTATION

Select implementers of reform: those implementing the first pilot phases of reform should not necessarily be the 'usual suspects' of existing innovators in the department. Do not attempt to force highly reluctant faculty to deliver any of the new courses at any point in the process.

Loosen direct link between faculty and individual courses: where possible, establish team teaching for all new courses, with regular rotation of faculty. Provide a dedicated forum for teams to meet.

Maintain momentum: ensure regular dialogue between faculty and change leaders. Ensure that the change is publicly noted as a priority by senior departmental and university management. Disseminate early successes internally and externally.

SUSTAINING THE CHANGE

Closely monitor impact data: continue to collect and monitor impact data for a sustained period. Continue to flag results, positive and negative, internally. Disseminate successes externally.

Make new faculty aware of the reform: ensure that all new faculty are fully aware of why the reforms were undertaken and the impact of the changes made. Assign new faculty to experienced teaching teams.

Establish an ongoing focus on education: ensure that the new curriculum is not stagnant. Engage in continuous development that keeps the curriculum at the cutting edge. Establish activities that are likely to engage a range of faculty. These will vary by context, but might include an engineering education research group, membership of international communities and/or faculty development workshops.

Be aware of potential issues: during university restructuring and/or changes to senior management place particular emphasis on above three tasks and communicate the drivers for and impact of the reforms to all faculty.

Appendix C: Extract from *Innovation with Impact: Creating a Culture for Scholarly and Systematic Innovation in Engineering Education*

Written by Leah Jamieson, the Dean of the College of Engineering at Purdue University, and Jack Lohmann, the recently retired Vice Provost for Faculty and Academic Development at the Georgia Institute of Technology (June 2012).

Published by the American Society for Engineering Education.

Full report available at http://www.asee.org/InnovationwithImpact

The report presents seven recommendations addressing the question of how can we build a stronger foundation for our engineering education enterprise, looking particularly at those elements that will ensure impact.

WHO

Recommendation 1: Value and expect career-long *professional development* programs in teaching, learning, and education innovation for engineering faculty and administrators, beginning with pre-career preparation for future faculty.

Recommendation 2: Expand *collaborations and partnerships* between engineering programs and (a) other disciplinary programs germane to the education of engineers as well as (b) other parts of the educational system that support the pre-professional, professional, and continuing education of engineers.

WHAT

Recommendation 3: Continue current efforts to make engineering programs more *engaging* and relevant and especially expand efforts to make them more *welcoming.*

HOW

Recommendation 4: Increase, leverage, and diversify *resources* in support of engineering teaching, learning, and educational innovation.

Recommendation 5: Raise *awareness* of the proven principles and effective practices of teaching, learning, and educational innovation, and raise awareness of the scholarship of engineering education.

CREATING A BETTER CULTURE

Recommendation 6: Conduct *periodic self-assessments within our individual institutions* to measure progress in implementing policies, practices, and infrastructure in support of scholarly and systematic innovation—innovation with impact—in engineering education.

Recommendation 7: Conduct periodic engineering *community-wide self-assessments* to measure progress in implementing policies, practices, and infrastructure in support of scholarly and systematic innovation—innovation with impact—in engineering education.