

Engineering Education-to-Employment: responding to a crucial shortage of engineering skills

A shortage of engineers in New Zealand and low numbers of students enrolling in engineering programmes is detrimental not only for business in this decade but for planning the growth of an innovative and productive economy. In response to this, the Government has allocated over \$60 million in the past four years to increase the numbers of engineering graduates by 500+ per year by 2017. The Tertiary Education Commission (TEC) established the Engineering Education-to-Employment (E2E) programme in June 2014 to help facilitate this goal. Initiatives undertaken through Engineering E2E contribute directly to the achievement of the Government's business growth agenda priority of building a more productive and economic economy.

National Engineering Education Plan

Concern about the shortage of engineers in New Zealand and the low numbers of domestic students enrolling to study engineering is not a recent development. The Institution of Professional Engineers New Zealand (IPENZ) undertook research in 2007 which identified a complex range of issues contributing to the long-term shortage of engineering skills and the need to ensure that engineering education met international best practice.

In 2008, the TEC funded a National Engineering Education Plan (NEEP) project to consider:

- A lack of clarity about pathways from school to engineering education and a lack of consistency in entry requirements
- Unclear career pathways, particularly in regard to Level 6 (New Zealand Diploma in Engineering (NZDE)) and Level 7 (Bachelor of Engineering Technology (BEngTech)) qualifications
- Difficulty in some tertiary institutions maintaining sufficient students to adequately cover specialist areas within the programme
- Insufficient coordination between disciplines and qualification levels for a national network of provision across all provider institutions.

The NEEP Governing Group was made up of representatives from: the New Zealand Council of Engineering Deans; the Council for Engineering Technicians and Technologists Education New Zealand; Industry Training Organisations (ITOs); industry; and IPENZ. It aimed "To develop a coherent national plan for ensuring the right

numbers of the right types of graduates were produced for New Zealand's needs." (NEEP Project Governing Group, 2010)

The NEEP project reviewed the Level 6-8 engineering qualification structure and divided engineering-related pathways into two career progression models – one for holders of engineering qualifications at Levels 6-8, and the other for holders of trade qualifications. It considered the demand for and supply of engineers with a Level 6 (NZDE), Level 7 (BEngTech) and Level 8 (Bachelor of Engineering (BE)) qualification and estimated that New Zealand would need 2,000 new graduates per year for 'business as usual' and 2,700 for an innovation-led economy.

The project found that: consistent advice is needed for senior secondary school students seeking entry or tertiary students seeking to move to higher level tertiary study; there should be greater awareness of issues for minority groups (Māori, Pasifika, women) in engineering education; and that there are significant barriers to entering and succeeding in engineering study so more work is required to extend and sustain support programmes.

The *National Engineering Education Plan Report (2010)* recommended that:

- The estimated demand of 2,700 engineering graduates should be used as a basis for future planning, with the largest increases needed in NZDE/BEngTech graduates
- TEC should target funding towards increased numbers of places in Level 6-8 engineering programmes
- TEC should only fund tertiary providers offering qualifications developed within the NEEP framework to ensure ongoing national consistency
- Ongoing work is needed between ITOs, the Ministry of Education and TEC to develop pathways from school to study to employment.

TEC sets up Engineering E2E

The findings and recommendations in the NEEP report set the target for engineering education and the TEC, recognising that education providers needed assistance to meet that target, established the Engineering E2E programme in partnership with the institutes of technology and polytechnics (ITPs), IPENZ, Business New Zealand and organisations that employ engineers or benefit from their services. Engineering E2E aims to

address the shortfall of students enrolling in engineering qualifications – particularly in Level 6 and 7 courses. A steering group, chaired by Sir Neville Jordan and made up of representatives from industry and education, guides a programme of work which includes: research; consultation with engineering educators, sharing of good practice, a secondary-tertiary pathways initiative; a public awareness campaign; and employer engagement.

Communication is key

Right from the start, communication has been a key component of the Engineering E2E project. Stakeholder groups, including engineering educators at ITPs, engineering-related professional bodies, industry organisations and government agencies, are kept informed about progress through monthly newsletters, website updates and at education and/or industry forums and workshops. They, along with any other interested groups, are invited to give feedback on aspects of the project and share relevant strategies for promoting pathways into engineering. Consultation with industry and education sector groups, IPENZ and other organisations around the issues linked to the shortage of domestic engineering graduates is a vital part of Engineering E2E's planning, and its research and recommendations are shared with the Minister of Tertiary Education, Skills and Employment to help inform Government policy.

Barriers to studying engineering

Before considering some of the solutions to increasing the numbers of students studying engineering, Engineering E2E first needed to more fully understand the barriers that prevent students from enrolling or succeeding in engineering study and commissioned Research First to investigate what those barriers actually are.

The research team first conducted a 'rapid review' of literature about engineering education and the barriers to study. It then held a series of informal scoping interviews with stakeholders and subject matter experts, including employers and academics. The emphasis of the research, however, and the source of its key primary data, was a series of focus groups held in Auckland, Hamilton, Nelson and Blenheim. The researchers ran 14 small focus groups comprised of school leavers, parents, STEM teachers and careers advisors, employers and/or mature students. Participants discussed their awareness of engineering, attitudes to engineering careers and any barriers they could perceive to studying engineering. The focus groups looked at the BEngTech

in particular, and those participants who were potentially interested in an engineering career for themselves or their children were asked why they weren't considering the BEngTech.

In their report *Engineering Barriers and Responses* (2014), Research First found that encouraging more students to study engineering at ITPs was a significant challenge because:

- There is little understanding of what a career in engineering means
- Engineering is perceived as an unattractive career
- Barriers to studying engineering are perceived as high; they occur early and are compounded during the progression through school to tertiary education
- Engineering careers have few champions
- The gendered nature of engineering reduces the number of potential students considerably
- Students interested in studying engineering had a clear preference for studying at university
- The engineering technologist role is poorly understood
- ITPs are strongly associated with the NZDE pathway into engineering, and the BEngTech does not fit well with this association
- Tertiary education providers are rewarded for thinking of their institution's needs ahead of the industry's needs.

In light of these findings, the report recommended:

- Marketing engineering to make it a more attractive career by:
 - Showing the wide range of engineering roles
 - Emphasising the problem-solving and creativity aspects
 - Showing engineering as an instrument of social change
 - Using role models to help shape students' career aspirations
 - Connecting with industry to demonstrate employment possibilities
 - Focusing on the international relevance of New Zealand qualifications.
- Building on current successful initiatives already working to raise interest in engineering as a career:
 - Futureintech Ambassador programme (IPENZ/Callaghan Innovation)

- 'Get a Life' careers month (Wintec, Connexis and Waikato Engineering Careers Association (WECA))
- Staircasing trades training into engineering careers (Wintec)
- Engineering Your Future camp (Massey University)
- Kidstech (CPIT)
- Engaging school students early so that they continue taking STEM subjects
- Enrolling schools in encouraging engineering careers
- Using industry to educate the educators
- Making a special effort to recruit female students
- Reimagining the BEngTech; a Graduate Diploma in Engineering Technology could be a better fit with both industry and students.

Alternative Engineering Pathways Professional Forum

In November 2014, the Engineering E2E Advisory Group convened a two-day Alternative Engineering Pathways Professional forum, hosted by Ako Aotearoa National Centre for Tertiary Teaching Excellence. Engineering education providers met to discuss pathways into engineering based on the background paper (Ako Aotearoa, 2014, November) prepared for the forum which included key questions around:

- How to increase the number of engineering technology students, particularly by providing more flexible access for students who are not fully prepared for the study
- Whether current programmes are effective in preparing students for engineering technology study
- If we can build current best practice to support the aim of attracting and retaining more students to engineering technology study
- Whether current entry requirements are fit for purpose.

The report on the forum (Ako Aotearoa, 2014, December) provided a number of recommendations:

1. That engineering providers collaborate on the sharing of good practice about specific bridging pathways to ensure that students have the opportunity to bridge into engineering study

2. That engineering providers should look for ways to improve motivation and success rates through innovative, research-led good teaching practice
3. That BEngTech providers consider collaborating with the NZBED [New Zealand Board of Engineering Diplomas] to add weight to industry involvement and improve pathways from diploma to degree study and to increase the number of cadetships in engineering study
4. That all teaching staff and students in engineering study be encouraged to become members of IPENZ
5. That engineering providers work proactively and collectively to build better relationships with their local secondary schools in collaboration with Futureintech
6. That senior engineering educators work proactively to develop agreements between providers for more enabling student transfer arrangements between providers to keep students in the engineering pipeline
7. That engineering providers, government and industry should work collaboratively on a unified publicity campaign to increase learner demand and this should be specifically targeted to under-represented groups
8. That engineering educators work proactively with industry, secondary schools and government agencies to develop a common set of flexible engineering-specific bridging courses or modules available to all secondary and tertiary students. These need to be sufficiently flexible to be used for multiple purposes and in multiple delivery modes: as the basis for preparation for engineering study while in school, bridging programmes, or just-in-time refreshers/preparation for students already undertaking study. Modules could be selected with guidance to complement students' existing strengths to ensure that each student has access to the most time-effective preparation for successful subsequent study.
9. That the TEC consider funding specific and targeted foundation courses free to students to encourage participation in engineering study
10. That the TEC fund the development of a suite of common flexible engineering bridging courses designed to enable greater participation in engineering study
11. That the TEC consider the development of increased scholarship and cadetship opportunities for study of NZDE and BEngTech programmes.

Metro BEngTech Research and Teaching Forum

Engineering E2E representatives attended the Metro BEngTech Research and Teaching Forum and the NZDE Forum in December 2014, where they presented the *Make the World* discussion document (Engineering Education-to-Employment, 2015), which summarised the challenges to increasing engineering graduates, and *Engineering Pipeline* diagram, which showed the stages where potential engineers are lost. Engineering E2E invited forum participants to give feedback on the documents and shared them on the Engineering E2E website (<http://engineeringe2e.org.nz>).

Engineering E2E resources

The Engineering E2E website informs readers about the purpose of the E2E initiative, provides progress updates, and showcases good practice and successful strategies used by employers and educators in the case studies section. The case studies cover aspects such as engineering education, promotional activities, workplace roles and other related issues; where applicable, they include suggestions for how other organisations could adapt or improve a strategy or activity. Three examples are:

- Mentoring Pasifika Engineering Students – discusses why Unitec appointed a Pacific Mentor to encourage young Pasifika people into engineering pathways and support them to achieve, how that role has evolved, and indications of its success.
- Practice-based Learning – looks at the New Zealand Council for Educational Research (NZCER) project in which construction apprentices, engineering cadets and general practice registrars were interviewed about their significant learning experiences in the workplace and making the connection between theory and practice.
- Defining engineering roles by qualification – looks at how one company recruits, makes use of and promotes its engineering staff, with opportunities often based on individual strengths rather than qualification type.

In addition to its own resources, Engineering E2E had gathered useful engineering-related reports and articles created by other organisations. The team decided to share what they had found and set up the Discoveries section on the website where readers can find: research reports commissioned by Engineering E2E or that

have informed its work; research from other organisations; relevant news articles and opinion pieces; and links to other initiatives which promote STEM education and/or engineering.

Work-ready Plus

Engineering E2E invited Emeritus Professor Geoff Scott, University of Western Sydney, to facilitate a workshop based on his involvement in developing a Professional and Graduate Capability Framework. The Framework was based on studies of successful graduates in nine professions and found that generic and role-specific competencies are not sufficient for effective early career performance and that personal, interpersonal and cognitive capabilities are important for success. Professor Scott emphasised that the capabilities listed in the Framework, such as “Remaining calm under pressure or when things take an unexpected turn” are learnable and produce what he calls ‘work-ready plus’ graduates.

Workshop participants considered the Framework in relation to what their sector requires of and values in graduates and discussed what could be incorporated into the design and delivery of engineering education. They also looked at the current and future challenges in engineering, and the capabilities that allow engineers to successfully cope with them.

Participants were keen to implement the ideas they had discussed in their own workplaces, and agreed that it was important to follow up the workshop to create an engineering-specific Framework. Five recommendations from the workshop have been accepted by the Engineering E2E Steering Group:

- Change the curriculum to incorporate the Framework, the opportunity for experience across engineering disciplines, and entrepreneurial experience
- Improve staircasing opportunities for students, potential students and those in employment
- That an engineering graduate study based on the Framework be replicated in the New Zealand context
- Follow-up with participants on ideas for contributions to a public awareness campaign
- Form a reference group to act as a conduit for ongoing advice and guidance from workshop participants.

The Steering Group has approved the establishment of an engineering graduate study led by Professor Scott to create an engineering-sector Framework.

Techlink Pathways Project

Students who might otherwise consider studying engineering at an ITP, or who enrol but struggle with the course, often lack the requisite maths and/or science to successfully complete the qualification. The Techlink Pathways Project (TPP) aims to help bridge that transition from NCEA Levels 2 and 3 into first-year tertiary study.

The project builds on the findings of a scoping project undertaken during 2013-14 by IPENZ, the Board of Engineering Diplomas and the Metro Group of ITPs. Project Leader Glynn McGregor interviewed stakeholders, including academic staff from Metro Group engineering departments, Technology, Maths and Science teachers, careers advisers, and employers in engineering-related industries, and liaised with the Ministry of Education's Vocational Pathways team. The *Techlink Pathways Project Statement of Intent* (McGregor, 2014) identified three key challenges: the need to align school and tertiary programmes so students can be better prepared to succeed in their studies; raising awareness of qualifications offered at ITPs; and addressing commonly held attitudes that studying at an ITP is inferior to university.

This year a TPP pilot initiative aims to generate interest in careers in the engineering and technology-related sectors by developing programmes of study for secondary students which offer a flavour of engineering and engineering study. Graham Carson, head of WelTec's Engineering School, is managing the pilot which involves clusters of schools and ITPs in Waikato, Wellington and Otago. Updates and case studies of collaboration that address the barriers identified by the scoping exercise will be published on the Engineering E2E website, and the programme will potentially be offered more widely in 2016.

Sponsored degrees

Sponsored degrees (also known as advanced or higher apprenticeships) which provide on-the-job training with completion of a degree-level qualification in engineering are increasingly being offered around the world. One of the advantages of this learning model is that it enables employer engagement in curriculum design and delivery, something which is particularly relevant to rapidly changing, high-tech industries such as engineering.

Engineering E2E commissioned research into advanced apprenticeships to find out what works, what doesn't, and whether any models could be successfully applied in New Zealand to deliver the BEngTech qualification.

Associate Professor Jane Goodyer and Dr Greg Frater of Massey University researched tertiary engagement in the form of advanced apprenticeships, conducting a literature review of learning models with high levels of employer involvement and interviewing tertiary providers involved in delivering degree apprenticeships.

Their report *Stepping into One Another's World: Apprenticeships – Transforming Engineering Technologist Education in New Zealand* found "The need for effective collaboration between employers and educationalists at the design and planning stage, and clear pathways to higher levels of education. Employers have to be in the driving seat, specifying degree standards that are outcome-based and occupation-driven." (Goodyer & Frater, 2015).

Goodyer and Frater endorsed apprenticeships as a viable model for educating engineering technologists and recommended:

1. Degree apprenticeships should be implemented as a viable learning model to educate engineering technologists
2. Government should co-fund these apprenticeships by giving money directly to employers
3. Apprenticeships should be specified by standards, developed as sector or occupation-defined outcomes and targeted towards helping the economy grow. The outcomes should link to sectors with fast evolving technology
4. A collaborative approach, between employers, professional bodies and ITPs should be used in the planning and design of these apprenticeships
5. Degree apprenticeships should have clear pathways to higher-level qualifications
6. Degree apprenticeships should be marketed as a new Gold Standard for educating engineering technologists
7. Degree apprenticeships should be named 'sponsored degrees'.

Conclusion

Engineering E2E initiatives are ongoing in order to support employers and educators in working towards the Government's goal of increasing the numbers of engineering graduates.

The Engineering E2E programme was established in response to a set of multi-faceted problems that couldn't be solved by tertiary education providers working by themselves. It has since gathered together an engineering 'community of interest' involving partners from across the learner 'journey' from education to employment – schools, tertiary educators, employers, business groups and bureaucrats – to seize any opportunities or solve any problems in achieving higher numbers of students enrolling in and succeeding in engineering study and moving into the workforce.

Engineering E2E provides an example of an approach to investment in education and training, and sets up a potentially replicable model.

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