AOTEAROA
NATIONAL CENTRE FOR
TERTIARY TEACHING
EXCELLENCE

# Improving Pathways to Engineering Education

## Summary Report

19 December 2014

# Executive Summary

This project forms part of the TEC Engineering Education to Employment (Engineering E2E) initiatives aimed at increasing the number of engineering graduates by 500 per annum from 2017.

The purpose of the Pathways to Engineering Education project was to explore with providers and learners ways to improve pathways to engineering study. This work comprised:

- a background paper that set out the key questions and issues that need to be addressed by providers, industry and government to improve pathways to engineering study;
- a professional forum for engineering educators held on 24/25 November 2014 that discussed key issues to advance discussion on improving pathways;
- a parallel series of interviews with current engineering students.

It was also informed by the recent Australasian Association for Engineering Education (AAEE) conference held 8-10 December 2014.

Thirty six students were interviewed as part of the project to examine their experiences with the current pathways to engineering study. The outcome of this research indicates that students who had undertaken a foundation or bridging course found this a positive pathway to engineering study and would recommend the bridging study to other students.

We conclude from the work as a whole that there are excellent opportunities for greater collaboration and leadership between the various participants in the engineering pipeline: secondary schools, tertiary providers, industry and government agencies to work together to provide strategic leadership to market, promote and facilitate engineering study.

Our recommendations from this work identify a number of positive initiatives that engineering providers, in collaboration with industry and government agencies, can take to increase demand for engineering programmes, particularly in the under-represented priority groups of Women, Māori and Pasifika learners. Such initiatives include the value of promoting engineering as a career choice and profiling successful engineers from these priority learner groups through a nation-wide marketing campaign.

Our recommendations include ways to encourage participation through the development of a common and more flexible bridging curriculum that may be delivered at both secondary and tertiary levels to ensure optimal transitions to engineering study for both secondary school students and mature students.

Our specific recommendations to TEC from this work are that TEC consider offering free pathway courses to engineering study and, possibly, the development of increased scholarship or cadetship opportunities for engineering study in diploma and degree programmes that incentivise success in these qualifications. We strongly recommend that the TEC fund the development of a common set of flexible engineering bridging courses designed to enable greater participation into engineering study.

## Contents

# Section 1 - Background to the Engineering Pathways project

## Introduction

TEC are leading a number of parallel initiatives to achieve the aim of increasing engineering graduates and this project was designed to make a positive contribution by examining how to (re-) open pathways for students and encourage participation through some creative solutions to enable more students to enter and complete the engineering education[1] pathways. The work was designed to complement other TEC initiatives as part of the overall Engineering Education to Employment project.

Given the project's focus of improving pathways into engineering study, a key aspect was looking at the issues from the student perspective. It was considered important to include the student voice as part of this project and therefore 36 students were interviewed to examine their experiences of pathways into engineering study and the issues raised are outlined under the Student Learning theme below.

As part of the project an Engineering Pathways Professional Forum was held on 24/25 November 2014 under the auspices of the *Engineering – Education 2 Employment* (E2E) initiative, hosted by Ako Aotearoa and the TEC, to facilitate a discussion about enhancing pathways into engineering to enable more students to participate successfully in the New Zealand Diploma in Engineering (NZDE) and the Bachelor of Engineering Technology (BEngTech). The participants of the forum are listed in Appendix 1.

From a learner perspective, effective alternative pathways will allow students with potential but lacking specific entry requirements to bridge into these programmes successfully. The forum looked at a range of issues including why there is a need to increase the numbers of students in engineering programmes; barriers and enablers both at the institutional and at the government policy level; a stocktake on what programmes providers were currently delivering to assist students into engineering study, some key themes that were outlined in background papers for the forum, emerging issues from student interviews, and some concrete proposals and recommendations to TEC for action to address the issues raised.

Dr Bruce Vandal, Vice President Complete College America joined the forum via a video link and shared his experiences of pathways for US students. A brief summary of his views and solutions are included under the Student Learning theme, as the US are experiencing many of the same issues as New Zealand in progressing students into STEM subject study.

At the 25th Annual Conference of the Australasian Association for Engineering Education (AAEE) Conference, TEC CEO Tim Fowler discussed the statistics detailed in Table 1 (below) and noted that

[1] For the purpose of the Pathways Engineering Education project *engineering* education refers to the NZ Diploma in Engineering (NZDE), the NZ Diploma in Engineering Practice (NZDEP) and the Bachelor of Engineering Technology (BEngTech).

even though government had increased funding for engineering study most of the additional funding had resulted in an increase in university numbers in engineering study, but not an increase in ITP numbers. However, as indicated in Table 1 the most pressing need for growth in student numbers is for technicians and technologists that are currently studying mostly at ITPs (in addition to the 13 ITPs, AUT University and the Queens Academy Group offer accredited engineering programmes).

Some of the more pressing concerns facing the government include the fact that only 13% of engineers are female and that of the 10,000 students that completed maths and physics at Year 12 study in 2012, only 12% go on to engineering education. (Fowler, 2014).

### *What is the problem we are trying to fix?*

The government has set a target of increasing the number of engineering graduates by 500 per annum from 2017. This figure is in response to the NEEP Project Governing Group (NEEP, 2010) estimates of the demand for and supply of engineers (2010-2015) in New Zealand. The NEEP Project Governing Group used four sources of data from the Department of Labour, the Ministry of Education, the OECD and feedback from industry to reach estimates of the likely future demand for engineering graduates. Two scenarios were selected; "business as usual", based on historic patterns, and the "innovation-led economy". The table below shows the estimates for each scenario and the percentage growth required to achieve these figures.

*Table 1: Demand estimates from the NEEP Project Governing Group (NEEP, 2010)*

| Qualification type | Actual qual. Completions in 2008 | Estimated annual needs-"business as usual" | Estimated annual needs- "innovation led economy" | Percentage growth required |
|---|---|---|---|---|
| Level 6 Engineering Technicians (Dublin Accord) | 270 | 500 | 750 | 85% to 178% |
| Level 7 Engineering Technologists (Sydney Accord) | 180 | 400 | 600 | 120% to 233% |
| Level 8 Professional Engineers (Washington Accord) | 1050 | 1100 | 1400 | 5% to 33% |
| Total | 1500 | 2000 | 2750 | 33% to 83% |

It was noted that the OECD country average for tertiary graduates with engineering qualifications as a percentage of all tertiary graduates is 12% and that currently New Zealand's rate of tertiary engineering graduates as a percentage of the total number of tertiary graduates is at 6%. It was also noted that even an increase for 500 engineering graduates from 2017 will still not achieve this 12% figure. Therefore, the government has an aspiration to increase the number of engineering graduates beyond 500 to become closer to the OECD country average. In general, the government wishes to increase both the number of engineering graduates and the *proportion* of engineering graduates compared to graduates from other disciplines.

This target will pose a challenge to all engineering educators but is necessary to build New Zealand into an innovation-led economy. The main purpose of this project is to develop some key recommendations to TEC to increase the number of students capable of completing an engineering programme that would otherwise be lost to the engineering pipeline.

The engineering pipeline through engineering education to employment is challenging and prone to *leaking* students along the way at a number of points. There are students with aspirations to take up engineering education study options but they are not well prepared for further study as there are inefficiencies for prospective students as noted in the report "Growing the pipeline of work ready engineering graduates" (TEC, 2013). Some of the barriers noted in this report include: failure to meet the entry criteria due to poor subject choice at school; insufficiently prepared to study at tertiary level; and a lack of public knowledge about engineering study and work options for graduates.

## A model of change

The overall aim of the project is to discuss ways to increase access to, and the effectiveness of, foundation pathways into engineering study, particularly for students that are capable of, but currently not participating in, engineering related study. It was agreed that in order to achieve 500 additional engineering graduates by 2017 some radical approaches to providing more effective preparation for are required to better prepare students for engineering study. Following on from more learners with better pathways, there is a need to keep more students in study through additional support if necessary to improve student retention and ultimately result in more engineering graduates. The following diagram (Figure 1) represents the overall aim of the project.

*Figure 1: Diagram representing the basic model of change for this project.*

# Section 2 - Key engineering pathway themes

In addition to the professional forum, the project was based on a number of key themes that were outlined in the background paper (Ako Aotearoa, 2014); interviews with 36 students currently in engineering study and also informed by work completed to date by TEC through the Engineering E2E project and other initiatives such as the Futureintech work sponsored by IPENZ and Callaghan Innovation. The key themes examined in this section are: student learning, external engagement, institutional issues, and policy and funding. Recommendations are listed under these key themes with recommendations for tertiary providers, industry and TEC noted in the sections below and summarised in Section 3 of this report.

# Theme #1 Student Learning

## Enabling greater numbers of students in engineering study

***Summary of findings from student interviews***

A total of 36 students were interviewed from 10 providers of engineering programmes. Note that due to the sample size, the responses should be considered indicative rather than a fully representative sample. Of these students there were 33 male students and 3 female students. The average age of the students interviewed was 28. This is indicative of the number of mature and second-chance learners undertaking engineering study. The students openly acknowledged that they required additional support and particularly, bridging study due to the number of years that they had usually been outside of formal education. On average the students interviewed had been out of school a total of 10 years. Of the students interviewed, 15 were currently (during 2014) NZDE students and 17 were BEngTech students. Note that 4 Bachelor of Engineering (Hons) students from AUT University were also interviewed as they had completed a foundation course at AUT prior to enrolment on the BEng (Hons) programme. AUT also offer a BEngTech option for students.

*Table 2 Students by qualification study*

| Students/Qualification | NZDE | BEngTech | BEng Hons | Total |
|---|---|---|---|---|
| Male | 14 | 15 | 4 | 33 |
| Female | 1 | 2 | | 3 |
| Part-time | 7 | | | 7 |
| Full time | 8 | 17 | 4 | 29 |
| School leaver | 2 | 5 | | 7 |
| Mature student | 13 | 12 | 4 | 29 |
| Cadets* | 4 | | | 4 |
| Students that took Bridging study | 9 | 9 | 4 | 22 |
| No bridging study | 6 | 8 | | 14 |

*of the cadets interviewed one was a school leaver and three were mature students.

Seven of the NZDE students were studying part-time and the rest were full-time students. Four part-time students were currently cadets working in the engineering industry and the other three

students were working part-time in the industry but not as cadets. The students that were both cadets and studying were generally very pleased with their situation due to the fact that their company was paying tuition, they were getting paid and studying, and their careers prospects were more certain with their current employment.

22 (61%) of the students interviewed had completed a bridging or foundation course prior to commencing their engineering study. The main reasons given for taking the bridging study were that they were required to undertake the bridging study as they had not met the entry criteria and/or that the student had been out of formal study for a significant period. Of those that had undertaken foundation study the unanimous verdict was that it had definitely contributed positively to their transition onto the engineering programme. Many of the students noted that they would not have made it in their engineering study without the bridging course.

Fourteen students (39%) did not take a foundation programme prior to engineering study. Of these, 7 students (50%) had progressed directly onto their engineering study without the need for a foundation programme as they had all been good at maths and physics at school, had met the entry criteria for direct entry and were generally confident that their prior study in STEM subjects was sufficient for engineering study without the need for a bridging course or other assistance. The other 7 students (50%) noted that they would have preferred to have done a bridging course if they had their time again. Of these 7 students, the reasons given were: that a bridging course was not an option at their provider (3 students); had been good at either maths or physics, but not both (3 students); one student had studied basic maths and science internationally but would have benefited from more engineering-specific study; in addition to the above reasons, four of these students also indicated that they had also been out of the study habit for a while and the bridging course would have helped with getting back into study skills.

Of the 36 students interviewed, 22 (61%) had changed careers into engineering from a different industry. Only 7 students (19%) had come to engineering study directly from school and the remaining 7 (19%) were in the engineering industry and increasing their qualifications. As noted above, this may not reflect a fully representative sample of all engineering students. All students interviewed were enthusiastic about their engineering study, and all were planning to stay in the industry. Many of the students indicated that they had found their career choice to be very satisfying and those that were not currently working in the industry were looking forward to working in the engineering field.

When asked what, if any, advice the students had received at secondary school about the subjects needed for engineering study the response was generally split by age. Twenty nine students (81%) had not received good advice at school about what subjects to take to help them in their career choice and the average age of these students was 28. However, it should be noted that many of these students had not considered an engineering career while at school and came to engineering study later in life. When asked further almost all said they had received little or no advice at school about career choices.

Notably, the seven students (19%) that *had* received good general careers advice had pursued those subjects at school, had done well in those subjects and progressed to tertiary study with a good preparation for engineering study. The average age of these students was 21. One of the female students interviewed, however, indicated that she went to an all-girls school in Auckland where engineering was never mentioned as a career option except by a male science teacher in year 9 that

recommended that she pursue an engineering pathway due to her proficiency in STEM subjects. She took that advice and is now studying the BEngTech at an Auckland ITP. She noted that, of the 200 girls in her graduating year only 2 had pursued engineering study. As noted earlier, the issue of female participation in engineering study could contribute significantly to the aim of increasing the number of engineering graduates. Options such as promoting engineering study at girls' schools and having some positive female role models of working women engineers could increase recruitment.

Given the lack of engineering-specific advice at school, there is clearly an engineering awareness issue that needs to be addressed by IPENZ and other organisations such as the Engineering E2E and Futureintech initiatives to promote engineering study as a viable option for students that are good at STEM subjects.

When asked about the transition from school to study, or school to work to study, most students had a positive narrative, although older students generally struggled more and many students reported that their lack of maturity after school contributed to their choices to delay study or to work prior to study. Of the 36 students interviewed, 23 (64%) had started study in a different field before changing to engineering study. All students interviewed indicated that engineering was now their career of choice and all intended to stay in the engineering field.

When asked about what advice the students would give to siblings or friends about their preparation for engineering study most of the students indicated the need to choose subjects wisely, do well in maths and physics study and also to study hard to keep on top of the workload. All students that had taken a foundation course themselves would recommend this pathway to students unless they had come straight from school having met the entry requirement directly. Another feature of the responses was the number of students that mentioned the need to develop good time-management skills as an attribute for successful study.

Following the forum, where the value of more flexible study options were discussed, students interviewed after the Forum were asked about their views on online learning and that if this option had it been available to them for foundation study, whether they would have opted for this method of learning. Of the 18 students that were asked this question, 7 (39%) gave an unequivocal yes to this option, 7 (39%) students said no, they would prefer face-to-face learning, and a further 4 (22%) said that online learning with tutorial support would be their preference. It was interesting to note that most of the students of the BEngTech study were currently involved in some kind of mixed-mode learning through a *Moodle* (or equivalent) platform and the reviews were mixed. Some students considered that more online learning would assist their study and life patterns providing greater flexibility for learning. Other students indicated a preference for face-to-face study.

Therefore in summary, some of the key points to note from student responses are:

- that students that study calculus and physics subjects at school are better prepared for engineering study and therefore there is a need for schools to offer good advice about subject choices and pathways towards engineering study, particularly with respect to the need to study calculus and physics;
- the benefits to students of cadetships to reduce study costs and have more security of employment;
- that many students change careers and take up engineering study later in life and that many students do not go directly from school to engineering study;

- the clear and obvious benefit of foundation study as a basis of successful pathway into engineering study for under-prepared students, particularly mature students;
- that all students interviewed appeared to be very satisfied with their choice of engineering as a career.

### *Specific needs of students that do not pathway directly from secondary school*

In addition to those students that are fresh from secondary school there are a group of mature students that have maths/physics credits but have been out of formal education for some time and need a refresher course or mature students who do not meet entry requirements but may work in the industry (have relevant experience). Both groups of mature students can benefit from foundation courses to bridge the gap to further study in engineering programmes.

Some recommendations from the Forum included arranging timetabling to better suit mature students with after work options and online options for bridging study. It was agreed that mature students have quite different needs from those out of school and need to be considered as a separate category of learner with appropriate adjustments by providers to cater to their needs. It was also noted that providers should attempt to attract trades students to engineering study as they are capable of adding good value and bring different experiences to the class. This pathway is available to trades students currently but very few take the option. Providing some proactive strategies may assist in attracting more trades students to engineering study.

### *What are the components of effective pathways to engineering study?*

There are a number of components of the pathways for students entering into engineering study:

- students that are still at secondary school and connect via the Vocational Pathways route;
- students that take STEM subjects and are well prepared for engineering study;
- students that take a pre-programme foundation or bridging course designed to meet the entry criteria for the engineering programme; students that take parallel study options to gain the prerequisite maths and physics credits as part of (or in addition to) their current programme study;
- students that utilise additional tutorial support available at the provider (or externally);
- integrated support provided to students within the curriculum (just in time or contextualised learning); and
- transition pathways from the NZDE to the BEngTech.

### *The US Complete College experience*

Dr Bruce Vandal, Vice President of the Complete College America gave a presentation to the Forum (Vandal, 2014). He noted that many of the issues facing New Zealand are common to the US. Some of the key strategies noted by Dr. Vandal to improve graduation rates through the "guiding pathways to success" (GPS) model include providing students with academic maths through the entire programme to help them navigate the subjects and papers necessary for successful completion; milestone courses that are essential for progression to ensure that students are keeping on top of key papers, and support available if not; proactive advising of students for completion of milestone

courses and achieving passing grades. Dr Vandal noted that the graduation rates had increased dramatically following the guiding pathways to success model, particularly for students from minority groups. Results from the GPS model have seen graduation rates from Georgia State University up 20% in the past 10 years with increased graduation rates for African American and Hispanic students. Dr Vandal noted that the key success factor was tutors using aggressive proactive advising to ensure that students stay on track in their study pathways. The full presentation is available on the Ako Aotearoa website for the Forum.

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

### *Motivational and pedagogical issues that impact on the effectiveness of current bridging pathways and programmes*

Forum participants discussed a significant cohort of unmotivated students and options to help these students including practical ways to improve motivation to succeed in foundation maths and physics classes. It was noted that in many case such students are capable of completing an engineering qualification if given the right support and environment to get through the basic maths and science study to meet the entry criteria. Some suggestions included: the need for tutors to provide more regular feedback to students; early identification of unmotivated students and early intervention with those students; the use of peer group and study groups to help students with study skills.

Some of the providers did not have data for student progression as they were either not teaching specific engineering bridging courses or the courses had just commenced in 2014. The 5 providers that had data for the students progressing from foundation courses to engineering programmes the following points can be made:

- Provider 1: the students that completed the foundation study generally perform as well as the students that achieved direct entry;
- Provider 2: course completion rates had increased steadily over the past three years for BEngTech study from 85% in 2012 to 94% in Semester 1 2014;
- Provider 3: student pass rates that had taken a bridging course and remained on the NZDE programme were 61% compared to 71% for direct entry students.
- Provider 4: students that took a foundation course in semester 1 2014, there was an 83% progression rate onto NZDE study and 100% progression rate onto BEngTech study.
- Provider 5: the NZDE successful course completion rate was 71% with a 71% student retention rate and for BEngTech successful course completion was 86% with an 81% retention rate.

One of the suggestions that came from the student interviews was the benefit of study groups with other students that have opposite skills sets where a student that was good at maths could help a student that was good at report writing and vice-versa. The benefits of soft-skill workshops and after hour sessions to assist students were discussed to provide students with the support and extra assistance needed to get through basic maths and science skills. The point was made that more advanced physics and calculus study is possible if a student has a grasp of basic maths and scientific

concepts. Other factors that would contribute to a positive teaching culture include recognition of good teaching and teacher awards for innovative practice (such as the Ako Aotearoa teacher excellence awards), peer support and conferences to share good practice, and also sharing resources across other providers. In their paper on improving the quality of undergraduate engineering programmes at the University of Technology, Sydney, Scott and Yates (2002) note the importance of providers developing key student capabilities in addition to technical expertise, including emotional intelligence capabilities such as teamwork, empathy and time-management. They note that to increase student motivation and engagement providers would do well do rely less on "assessment of routine skills and facts and more on tracking of how well students can use their technical expertise in combination with their emotional and intellectual capabilities to diagnose and resolve effectively specific workplace problems and common dilemmas" (Scott and Yates, 2002). A similar point was made by Roger Hadgraft at the EEAA Conference (Hadgraft, 2014) where he talked about the need to redesign the engineering curriculum to make it much more project/task oriented and personalised, where students engage in complex tasks with real-world applications to add value to their learning experience and better prepare for an engineering career. Providers preparing students for engineering pathway study in New Zealand could improve retention and completion rates through similar strategies to increase motivation of learners and provide a more personalised pathway to engineering study.

**Recommendation 2: That engineering providers should look for ways to improve motivation and success rates through innovative research-led good teaching practice.**

# Theme #2 external collaboration

It is clear from the various parts of this projects that there is a need for greater collaboration between the various participants within the engineering pathway. The section below looks at some of the key partnerships and ways to improve collaboration between industry, providers and secondary schools.

## Collaboration between tertiary providers and industry

The Engineering E2E initiative provides an excellent opportunity to improve the access to and effectiveness of pathways to engineering programmes and to improve the collaboration between industry and engineering providers. One suggestion from the forum was for the BEngTech providers to consider an industry leadership model, similar to the model currently operating with the NZDE and the New Zealand Board for Engineering Diplomas (NZBED) with a unified oversight over the NZDE and NZDEP. The form discussed the pros and cons of such an independent leadership body comprising of members from industry providers and also including secondary school membership to improve collaboration and secondary/tertiary links. One option is for the NZBED to also oversee the BEngTech qualification so that it has oversight for the full range of engineering qualifications.

The forum considered that increasing the number of cadetships available to engineering students would be a win-win solution for students, providers and industry. One option to increase participation would be to arrange cadetships through a centralised hub for all providers. As noted in the section above, students that were currently cadets working part-time and studying in the NZDE programme were very enthusiastic about their cadetships and the benefits available to students such as tuition costs, a part-time income and the prospects of employment within the engineering firm following graduation.

**Recommendation 3: That BEngTech providers consider collaborating with the NZBED to add weight to industry involvement and improve pathways from diploma to degree study and to increase the number of cadetships in engineering study.**

The forum discussed the benefit of encouraging IPENZ membership particularly for staff and students. It was noted that although IPENZ has a more specific interest in professional engineers, that because they were also responsible for the approval of all engineering qualification in question they had a clear role to play in promoting staff and student participation in IPENZ membership. This factor was seen as a positive advantage for a number of students interviewed that cited the benefits of links with IPENZ while still studying to improve networks, improve job prospects and also to keep abreast of current developments in the profession. Other suggestions from the forum was the view that providers should utilize more part-time staff that are current engineering practitioners and for providers to encourage more mentoring by current engineers so that students can get a better perspective on the practical context of their study.

**Recommendation 4: That all teaching staff and students in engineering study be encouraged to become members of IPENZ.**

## Collaboration between tertiary providers and secondary schools

The forum discussed the apparent disconnect between secondary schools and providers and the need to improve collaboration with local secondary schools. The forum discussed some of the barriers to the secondary/tertiary interface particularly some of the difficulties in establishing and maintaining good relationships with secondary schools. Several of the ITP providers noted that relationships with local schools had improved markedly by personal contacts and presenting engineering pathway options directly in the school classroom.

It is clear, and reinforced by the student interviews, that many students in NZ secondary system are largely unaware of options for engineering pathways, and that there is a lack of profile to engineering career options at many schools. It was noted that ITPs can reach-out to their local schools to build on initiatives such as the MoE Vocational Pathways to improve the profile of engineering options and assist their local schools to appreciate the options available to schools. The recently published Research First report Engineering Barriers and Responses (Research First, 2014) that was commissioned by the Engineering E2E team demonstrates some of the challenges that exist in encouraging students to study engineering at institutes of technology and polytechnics (ITPs). Some of those barriers include a preference for studying at a university, the leaky pipeline, and lack of awareness about the engineering profession or study options for engineering.

There is a need for greater awareness by secondary schools and career counsellors of the benefit of advising students on good subject options needed for engineering study and career progression. Some options include developing a “roadshow” to stimulate interest, particularly with the use of positive role models; perhaps increasing the profile of pathway progression by building on vocational pathways model for schools to advise students.

It was noted that the Minister of Tertiary Education, Skills and Employment Hon Steven Joyce had requested that TEC write to ITP CEO representatives on the Engineering E2E project advising them of the outcome of the Research First Report on barriers to engineering study. In the letter (dated 24 November) TEC notes the involvement of Minister of Education Hon Hekia Parata regarding issues that the report raises about schooling sector and careers advice to pathway to engineering study. The letter also invites ITPs to discuss and provide responses to build on the work of the Engineering E2E project to re-engage STEM students at school about the benefits of engineering study and careers and looking for ways to address the report’s recommendations.

The forum spoke about Futureintech that plays a very useful role in disseminating information to schools. However, it was noted that in order to have meaningful dialogue with schools across the country, organisations will need to provide many more resources to the problem of lack of awareness (or interest) in engineering career pathways. The potential of a few key *engineering ambassadors* could make a significant impact by disseminating information at secondary schools. In addition, as has been shown with the student interviews, industry ambassadors visiting schools can make an impact by generating interest with school students and ensuring that they are aware of the school subjects that will give them the best possible start into an engineering study pathway. It was noted that individual engineering providers must also make the effort to connect with local school principals, advisors, teachers and parents where possible.

**Recommendation 5: That engineering providers work proactively and collectively to build better relationships with their local secondary schools in collaboration with Futureintech.**

## Collaboration between engineering education providers

The forum participants noted the importance of keeping the student central to the pathway so that the student and his or her career is seen by all participants as the most important priority. From this perspective the collaboration to ensure student pathways into engineering study should enable students to follow the best pathways to enable their success. The forum discussed the fact that many young people from the regions are not able (or willing) to relocate straight from school. Therefore a good pathway for them would be study of the NZDE at their home provider with an articulation pathway to an ITP or university offering BEngTech or BEng options.

Similarly, a number of students that start study at a university but do not progress (due to a number of reasons) may be better off studying at an ITP or BEngTech provider. There is a concern that too many capable students may be lost from the engineering pipeline unless this type of cross-sector transfer is both encouraged and supported. There was concern that the current funding model encourages providers to keep students and channel them into alternative study rather than see the career of engineering as the destination for the benefit of the student.

Some practical steps could be the development of articulation agreements between level 6 and 7 providers with level 8 providers of the BEngTech to promote smooth transitions and pathways between providers. The participants agreed that developing good personal relationships between heads of schools and providing clear communication and open pathways would contribute to the overall aim of increasing participation in engineering related study and graduation rates.

**Recommendation 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.**

## A collaborative approach to leadership

The forum discussed the need for ITPs (and other providers) to work collaboratively with IPENZ to take a collective leadership role, to improving pathways to engineering qualifications. The fact that the engineering profession is a significant industry for international portability is a huge plus with students.

As discussed above, IPENZ and TEC are taking a strategic role in promoting the benefits of cadetships to engineering firms and selling these benefits to potential students through the work of the Engineering E2E project and the Futureintech programme for schools liaison. There was discussion in the provider forum for the need to jointly develop a nation-wide marketing campaign involving IPENZ, government departments and providers to educate and raise awareness of the multiple different roles that engineering plays in society, the value of engineering to the development of New Zealand as a nation. It was noted that such a campaign to increase participation in engineering study would need to be matched by capability in the sector and within industry to take on the additional graduates from 2017.

The forum noted the need to collectively promote some key messages to industry, providers, schools and government agencies so that there is a common understanding for the need for growth

in engineering graduates. The Group discussed the need for engineering firms to become partners with providers in the development of skills (particularly through cadetships) through a collaborative approach to skills development to help build partnerships between local industry and providers, raise awareness and improve pathways for students and make employers part of the solution.

### *What groups of students are the key target for pathways to engineering study?*

The target market categories of students for engineering pathways include: recent school leavers; mature students; workers currently in the industry wishing to upskill; international students and students that have not traditionally chosen engineering study such as Women, Māori, Pasifika learners. The background paper detailed the fact that there were fewer women, Māori and Pasifika learners in engineering study. The Forum participants discussed ways to increase participation of these priority groups into engineering study by identifying and appealing to career motivations and linking those with options available to engineering careers, such as the public good and society benefits that engineering solutions can provide to society as a whole. There was a general feeling that there is lack of effective co-ordinated effort in this area.

The Group suggested that a national campaign that promotes a positive story and profile women in prominent engineering positions would assist with recruitment. One of the female students interviewed indicated that she thought that such a campaign would really help to attract more women into engineering study and raise the awareness and profile of engineering options for women. There was discussion of the Georgia Institute of Technology in the US which is the number 1 university in the US for women in engineering. The Georgia Tech website (http://wie.gatech.edu/home) includes many examples of women in engineering study and the career choices and the options available to graduates.

A targeted publicity campaign could be used to encourage pathways to engineering study, by using student success stories and the number of career options and the positive perspective of students involved in engineering study which was so evident from the students interviewed. It was noted that women make up over 50% of the tertiary education market and therefore a key focus for all stakeholders should be to encourage more women to enter the engineering profession.

There was discussion about the nomenclature of “foundation” course which often has a negative connotation with students. There was clear support at the Forum for keeping away from this title in favour of course names that include the term engineering, such as “Preparation for Engineering” or “Engineering Online” or “Certificate in Technology for Engineering”. The Group agreed that it was more beneficial to market the *career* of engineering rather than the *programmes* that lead to the career.

**Recommendation 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.**

# Theme #3 Institutional issues

## Curriculum

### *Current engineering foundation programmes*

The forum discussed the benefits of different types of foundation programmes currently. It was clear that across the providers there is a wide variety of options for foundation courses ranging from 4 or 5 week summer courses, to one semester bridging courses to full-year foundation courses. There was discussion about the benefit of a more common pathway that would be available flexibly to tertiary students and also available to secondary students wishing to prepare for engineering (or related) pathways. Such a common course (or set of papers) could be delivered flexibly by mixed-mode, face-to-face or fully online. The forum discussed the fact that the NZQA targeted review of qualifications (TRoQ) would be a good opportunity to review the current foundation options into a more common qualification. With an agreed set of learning outcomes a New Zealand foundation certificate in engineering would provide a coherent and standardised pathway into engineering study.

It was generally agreed that the current entry requirements into NZDE and BEngTech programmes are fit for purpose. However, the entry requirements may create unnecessary barriers to students that are capable of studying engineering programmes. The pathways to NZDE study are accepted as appropriate and enabling for student participation as they bridge well from secondary school NCEA credits at level 2 including 12 credits in maths. The level 3 entry requirement of 14 credits in calculus is a little more problematic due to the fact that some secondary schools do not offer calculus as a subject. However, it was agreed that this presents an opportunity for tertiary providers to offer assistance to schools to help with transitions to higher level maths subjects.

The forum participants discussed the pros and cons of short courses. For many students a short-sharp revision of prior learning is all that is required to bridge successfully to engineering study. However some participants considered that 4 or 5 week programmes did not offer sufficient content to embed difficult concepts. However, as noted previously student learning is done in a variety of different ways and for some providers the short course options offer a useful bridge for many students, particularly those that had just missed entry by a few credits.

Short courses are unlikely to suit many learners that had been out of formal education for a while. This view was reinforced by students interviewed that had completed foundation study where 59% of students had completed a one-semester (17 week) course as a bridge to higher engineering study.

The provider forum discussed the issue of adding additional maths and physics credits into existing engineering programmes (a *just-in-time* approach) which should be considered to assist those students that needed additional assistance within existing engineering programmes as specific maths and physics capabilities are required.

### *Common and flexible opportunities for foundation learning*

One option that was discussed at the forum was the possibility of offering a common set of foundation papers that would be made available throughout New Zealand to all providers and secondary schools that would be purpose built for engineering-specific maths and physics preparation for engineering study. These papers would be available flexibly for online delivery,

mixed-mode delivery or face-to-face delivery and include video presentation of basic concepts. There are some good models such as the Khan Academy (https://www.khanacademy.org/) that offers basic maths or advanced calculus and physics study. The benefits of a common set of resources would be that they can be developed centrally and shared across all providers and secondary schools to encourage participation in engineering study. This would also have the added benefit of enabling access to basic STEM subjects that would be beneficial across a number of related disciplines. The forum considered that making these foundation courses available free of charge to students would be a significant inducement to students.

It is envisaged that combining resources and offering more flexibility will also reduce the need for individual providers to have minimum class levels for financial viability and classes and resources would be shared by a large number of tutors, teachers and providers with good economies of scale and associated cost savings. The fact that the courses would be available at schools also means that secondary students can start to accumulate relevant credits that serve both NCEA purposes and credit towards engineering study in a tertiary institution. This will be of significant benefit to schools and students and provide a concrete example of the MOE Vocational Pathways initiative for planning pathways to higher level study from secondary school. It will also assist smaller schools that may not have sufficient staffing resources to offer specialist maths subjects such as calculus.

The forum discussed the possibility of using incentives for secondary school students to follow STEM subject pathways to gain credits in these subjects, even possibly weighting the STEM credits as holding more value. The most important factor, however, was to ensure that students are well advised and have an academic "map" to ensure a greater level of awareness of both the value of, and the potential pathways that are available to students with a solid grounding in STEM subject choices.

**Recommendation 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 student's existing strengths to ensure that each student has access to the most time effective preparation for successful subsequent study.**

# Theme #4 Policy and funding

### *Funding foundation education*

The forum participants discussed some of the barriers related to the funding of bridging courses and some possible solutions. It was agreed that the current funding mechanisms are not currently set up to encourage bridging study to engineering to the extent likely to encourage participation of 500 more engineering graduates by 2017. It was agreed that as with discussion earlier in the day some more *radical* approaches are required to meet this goal.

Given the priority government places on STEM subjects and qualifications, a case may be made for flexibility to enable short course funding for courses leading to engineering programmes. This would require a change to the student achievement component (SAC) funding rules. Currently the rules around provision of training schemes may limit a providers' ability to offer flexibility to individual student needs as training schemes are required to be approved by NZQA for eligibility. A more flexible approval system, would assist providers in offering the type of bridging course to increase access, retention and success. It was also noted that foundation funding rates are low by comparison to engineering funding rates and should be increased for engineering-specific bridging programmes.

### *Incentivise learning for bridging courses*

It was noted that currently short courses such as *summer maths* and *maths boot-camp* courses are currently funded by student fees and this provides a disincentive to student participation. The longer semester or year-long foundation courses can cost between $2,500 and $6,000.

The forum discussed the need to incentivise students into pathways for engineering study through the provision of free courses funded by government for bridging study. It was suggested that any bridging course leading to engineering study should be free to students to encourage participation. The payments would effectively follow the student and would be available to any bridging course to engineering study. The forum considered that as with scholarships this would be an investment in the engineering industry and make a significant contribution to the aim of increasing the number of graduates by 500 in 2017. This would also have the effect of increasing participation of target market groups such as women, Maori and Pasifika. Under this option student allowances would also be adjusted so that additional bridging study would not affect the students' overall student allowance allocation.

**Recommendation 9: That the TEC consider funding specific and targeted foundation courses free to students to encourage participation in engineering study.**

### *National funding for flexible common provision*

A strongly supported recommendation is for TEC to consider funding the development of a suite of common flexible engineering bridging courses (as per recommendation #8) at a national level as a pilot project. This nation-wide initiative would involve educators from tertiary and secondary sectors to develop engineering-specific maths and physics papers for delivery at secondary schools and tertiary providers in a mixed-mode flexible delivery method specifically targeted to students as a bridge to engineering study. The resources would be available to any student and be developed by

providers and managed by a central government agency (for example under the TEC Engineering E2E initiative).

The forum considered that this would be a long-term investment designed to support pathways to engineering study and employment over many years. Providing such courses would also help solve the problem of each provider needing to meet a critical mass of students to ensure economic viability of programmes. The benefit would be a reduction in overall foundation education spending (allocated to individual providers) and these savings could be used to develop the common flexible resources.

**Recommendation 10: That the TEC fund the development of a common set of flexible engineering bridging courses designed to enable greater participation in engineering study.**

### *Scholarships and cadetships for engineering study*

The Forum participants discussed the possibility of government assisting with the development of increased numbers of scholarships to encourage students into the engineering education pipeline. The scholarships would be targeted to engineering study for NZDE and BEngTech programmes and be available throughout New Zealand as part of a marketing campaign to encourage greater participation in the engineering industry. The forum believed that the scholarships would be affordable and an excellent investment for government to encourage participation in engineering study.

In addition to assistance with the development of scholarships, the forum recommends that the TEC work with the engineering industry and employers to promote and encourage a greater number of cadetships offered for NZDE, (NZDEP) and BEngTech programme study to encourage education opportunities and build closer links between students, providers and the engineering industry.

**Recommendation 11: That the TEC consider the development of increased scholarship and cadetship opportunities for study of NZDE and BEngTech programmes.**

# Section 3 – Summary of Key recommendations

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

**Recommendation 2:** That engineering providers should look for ways to improve motivation and success rates through innovative research-led good teaching practice.

**Recommendation 3:** That BEngTech providers consider collaborating with the NZBED to add weight to industry involvement and improve pathways from diploma to degree study and to increase the number of cadetships in engineering study.

**Recommendation 4:** That all teaching staff and students in engineering study be encouraged to become members of IPENZ.

**Recommendation 5:** That engineering providers work proactively and collectively to build better relationships with their local secondary schools in collaboration with Futureintech.

**Recommendation 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.

**Recommendation 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.

**Recommendation 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 student's existing strengths to ensure that each student has access to the most time effective preparation for successful subsequent study.

**Recommendation 9:** That the TEC consider funding specific and targeted foundation courses free to students to encourage participation in engineering study.

**Recommendation 10:** That the TEC fund the development of a suite of common flexible engineering bridging courses designed to enable greater participation in engineering study.

**Recommendation 11:** That the TEC consider the development of increased scholarship and cadetship opportunities for study of NZDE and BEngTech programmes.

# Appendix 1 List of Forum participants

### *Participants at the Engineering Pathways Professional Forum*

The Forum was developed for providers of the New Zealand Diploma in Engineering (NZDE) and the Bachelor of Engineering Technology (BEngTech) specifically because of the greater need for growth in these qualifications as noted in Table 1 above. It should be noted that the Bachelor of Engineering Honours (BEngHons) is taught at a number of universities and that there are clear pathways from secondary school to the BEng (Hons) based on specified entry criteria, with healthy numbers of applicants each year. The aim of the Forum was to examine pathways to engineering study and therefore it was not considered necessary to include BEng Hons providers at this particular forum.

The Forum included participants from 12 of the 15 providers of NZDE and BEngTech programmes as well as staff from central agencies and stakeholders. Each of the providers presented to the forum the current pathways available to students of NZDE and BEngTech study and an overview of these current pathways is available in the background paper that is also on the Ako Aotearoa website.

| First name | Last name | Organisation |
|---|---|---|
| Graham | Carson | Wellington Institute of Technology |
| Robert | Dantzer | CPIT |
| Michael | Edmonds | CPIT |
| Malcolm | Fair | Wellington Institute of Technology |
| John | Findlay | Otago Polytechnic |
| Trudy | Harris | Wintec |
| Gavin | Jack | UCOL |
| Jeff | Kilby | AUT University |
| Wei | Loo | Unitec |
| Michael | Mullany | NorthTec |
| David | Nummy | Unitec |
| David | Nutt | AUT University |
| Richard | Nyhof | Otago Polytechnic |
| Christo | Potgieter | The Open Polytechnic |
| Doug | Rodgers | Otago Polytechnic |
| Warren | Ruwhiu | Southern Institute of Technology |
| Joyel | S. John Stephen | Southern Institute of Technology |
| Vijen | Subramoney | Queens Academic Group |
| Charles | Tsui | Manukau Institute of Technology |
| Shelley | Wilson | Wintec |
| Bill | Sole | Competenz |
| Glynn | McGregor | Futureintech |
| Brett | Williams | IPENZ |
| Sharon | Wagg | Metro BEngTech Coordinator |
| Angela | Christie | Tertiary Education Commission |
| Murray | Johnson | Tertiary Education Commission |
| Ken | Wilson | Contractor Ako Aotearoa |
| Peter | Scanlan | Contractor Ako Aotearoa |
| Peter | Coolbear | Ako Aotearoa |
| Nyk | Huntington | Ako Aotearoa |

# Appendix 2 Useful websites

Ako Aotearoa website: https://akoaotearoa.ac.nz/

Careers NZ website: http://www.careers.govt.nz/

Competenz website: http://www.competenz.org.nz/

Complete College America website: http://completecollege.org/

Engineering Education to Employment (E2E) website: http://www.engineeringe2e.org.nz/

Futureintech website: http://www.futureintech.org.nz/

Futureintech advice for bridging courses: http://www.futureintech.org.nz/bridging-courses.cfm

Futureintech Engineering pathways: http://www.futureintech.org.nz/engineering-pathways.cfm

Georgia Tech Women in Engineering: http://wie.gatech.edu/home

IPENZ website: http://www.ipenz.org.nz/ipenz/

The Khan Academy: https://www.khanacademy.org/

Metro Group website: http://www.metros.ac.nz/

Ministry of Education: Vocational Pathways website vocational pathways

NZBED website: http://www.nzbed.org.nz/

NZDEP ITO providers: http://www.nzbed.org.nz/nzdep/how-to-enrol/

Techlink Home Webpage: http://www.techlink.org.nz/index.cfm

Techlink Pathways Project website: http://www.futureintech.org.nz/enews/schools/story.cfm?ID=27

Technology Education NZ (TENZ): http://www.tenz.org.nz/

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