Research First

E2E Engineering

Engineering Barriers and Responses

Research Report

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RESEARCH ASSOCIATION NEW ZEALAND MEMBER COMPANY

Research First

Contents

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1 Key Messages

Encouraging more students to study Engineering at ITPs presents a significant challenge

This research shows that encouraging more students to study engineering at ITPs is a significant challenge. This is because:

- There is little understanding of what a career in engineering means in 2014.
- The barriers to studying engineering occur early, and are compounded during the progression through school.
- Among those students who retain an interest in studying engineering at the tertiary level there is a clear preference for studying engineering at a university.
- ITPs are strongly associated with the NZDE pathway into engineering, and the BEngTech fits uncomfortably with these associations.
- Tertiary education providers are rewarded for thinking of their institution's needs ahead of the industry's needs.

This analysis suggests that the challenges facing ITPs are systemic and deep-seated. The response suggested by this research is two-fold. The first addresses how the BEngTech qualification is marketed, and the second (more fundamental response) addresses the assumptions behind the BEngTech product itself.

The marketing response required is three-fold. It needs to address:

1. How to generate greater interest in engineering as a career.
2. How to convert this interest into study intentions.
3. How to position the ITP as a preference within these study intentions.

This research is clear that, for each purpose, the marketing response needs to work through the classic 'engagement cascade' (Figure 1.1). Some suggestions for how to do this are contained in Section 5 of this report.

1.1 Engagement Cascade

The second response focuses on product development, and starts from the implication that the BEngTech as currently configured may be at odds with what the market seeks. This research suggests that a Bachelors qualification aimed at 'technologist' roles makes assumptions about both supply and demand that may not bear scrutiny. Instead, this research suggests that a Graduate Diploma in Engineering Technology could be a better fit with both industry and students.

2 Research Design

The research reported here used a multi-method design, and involved a comprehensive research project

2.1 Context

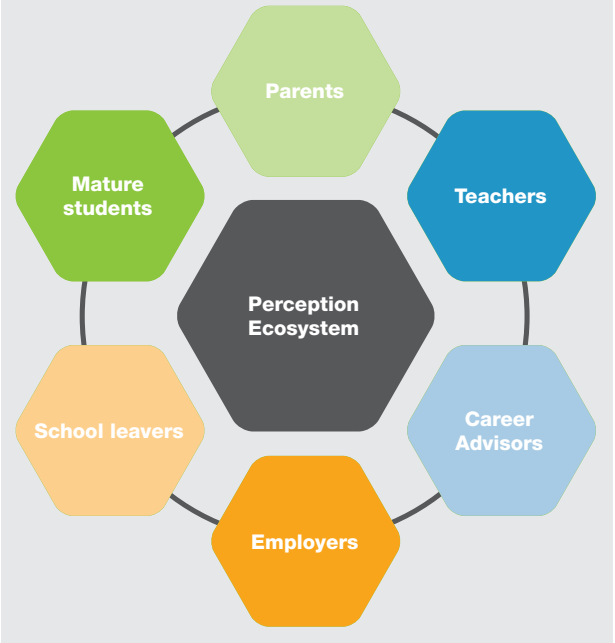
The Government's Engineering Education-to-Employment (E2E) initiative is aimed at increasing the number of students enrolling in engineering qualifications at institutes of technology and polytechnics (ITPs). The initiative is a recognition that industry needs more engineering technicians and technologists, and hence more students to choose these pathways into engineering. E2E will involve a marketing campaign aimed at raising awareness of the variety of pathways into the industry, and will target both students and influencers (such as parents, teachers, and careers advisers).

Wintec and the other ITPs in the Metro Group hope to benefit from the E2E initiative by aligning their own marketing messages to those in the nationwide campaign. However, what is unclear to both Wintec and the other Metro Group ITPs is whether E2E (or the National Engineering Education Plan4 in general) fully understands the reasons why students have not been drawn to engineering study in the past. To address this, in September 2014 Research First conducted research to better understand how marketing messages and product delivery can be developed to address the barriers to study.

2.2 Method

This research is about better understanding how to get more students to choose careers in engineering that involve the need to study at an ITP. Achieving this means better understanding the 'perception ecosystem' shaping students' choices. This includes the views of parents, teachers and career advisors, employers, and students (both school leavers and mature students). The 'ecosystem' perspective enabled the research team to test what the various groups know about the reality of employment in engineering in 2014, and to understand how this shapes their perceptions.

2.1 The Perception Ecosystem



The research reported here is the product of a substantial research project (albeit one completed with considerable time constraints for delivery). This project involved:

1. **A rapid review of the literature about engineering education** (and the barriers to study). As the name suggests, 'rapid reviews' are literature reviews that use accelerated methods compared to traditional systematic reviews. The demand for rapid reviews are usually driven by tight timeframes. The evidence of efficacy for rapid reviews suggests that the conclusions drawn from these reviews tend not to vary from systematic reviews. However, as one would expect, they do not provide the same depth of insight or detail as traditional systematic reviews[1].
2. **A series of informal scoping interviews** with stakeholders and subject matter experts (including employers and academics).
3. **Fourteen (14) focus groups** (see below).

The key primary data for this project were collected from the focus groups. This approach was chosen because of the need to explore complex issues in depth.

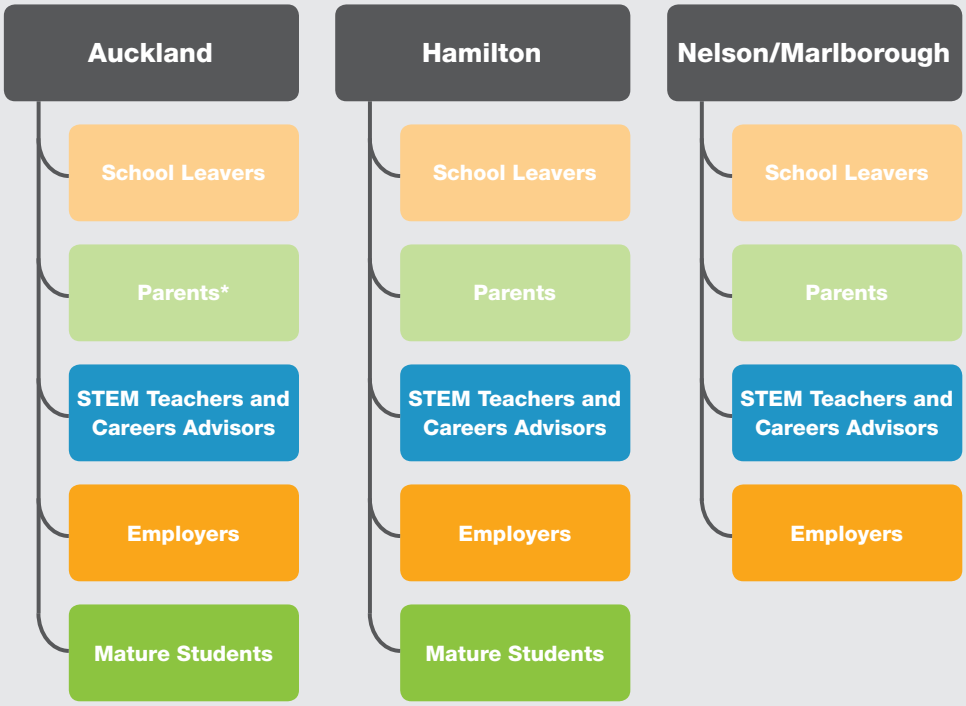
Focus groups essentially provide a facilitator-led discussion with a small number of participants. The intimate size of the groups coupled with the use of probing, open-ended questions provides several key advantages:

- They provide a social process for the discovery of insights. Interacting with other people is a natural part of everyday life, and focus groups allow people to discuss their opinions in a more natural, real-life setting.
- They are designed to be both flexible and spontaneous. Conversations between participants are encouraged to follow their own organic paths through various topics, allowing the research team to discover new ways of looking at the question.
- They provide an authentic insight. The related group setting means participants feel confident to share unique, detailed insights which can sometimes not be achieved using other research methods.

To help the research team gain a broader perspective of attitudes toward engineering study, fourteen focus groups were conducted in Auckland, Hamilton, Nelson and Blenheim. This design enabled the research team to explore the views of the key groups in the perception ecosystem, in different places around New Zealand. The focus groups were conducted between 15th and 18th of September, 2014. (Figure 2.2)

1. National Collaborating Centre for Methods and Tools. *Methods: Synthesis 1 Rapid Reviews: Method and Implications*. Hamilton, Ontario.

2.2 The Focus Group Sample



*Parents in Auckland were contacted by telephone interview

3 Why Don't More People Study Engineering?

3.1 Engineering is Not Well Understood

This research is clear that there is widespread confusion about what engineers do and what an engineering career might look like. Moreover, there is tendency to make assumptions about engineering which may lead multiple players in the perception ecosystem to discount engineering early. In other words, many of the participants in this research did not understand what engineering involves, nor how large the field is.

It is also clear that there is no common language to describe careers in engineering. The label 'engineer' is broadly used to refer to a range of occupations, from tradespeople and technicians to professional engineers. As one parent put it:

'Engineer' means the hands-on guy in the workshop all the way to the top-end engineer in their office.

The literature review completed for this research is clear that this is not the case internationally. Elsewhere, the term 'engineer' has a more distinct meaning, and different roles can be described accurately. The difference in New Zealand may be due to the comparative size of the industry, and the number of roles historically played by a single engineer[2]. This also may have been shaped by competing engineering traditions – for example, the English tradition of engineer-as-tinkerer, compared to the German tradition of professional engineering.

Additionally, there is a lack of comprehension of the different engineering disciplines. Participants emphasised that 'most people' thought engineering was just civil engineering. A first-year student noted:

When you tell people you're studying engineering they tend to think of civil engineering – building bridges or buildings. Worse, if you say you are studying 'mechanical engineering' they think you are training to be a mechanic.

Another student said:

People don't get that engineering is a very wide field.

This confusion was present even among those students intending to study engineering. While some had an idea of the range of engineering disciplines, others were unsure about what 'counts'. One student acknowledged this, saying:

You don't really know what engineering really is…you find out in University.

2. IPENZ, *The Demand for and Supply of Engineers*, retrieved from http://www.ipenz.org.nz/IPENZ/forms/pdfs/Final_Statement_on_Demand_and_Supply.pdf

Parents were similarly confused. Some parents were involved in the industry, but were usually only clear about what engineering meant in the narrower context of their work. Other parents had very little understanding about what is involved in 'engineering'. One participant commented:

It's not that it's not sexy, it's that they don't think of it at all.

STEM teachers tended to know more than parents about the range of engineering disciplines. In some cases, their understanding was limited to disciplines available as specialisations in a Bachelor of Engineering (BE) (because they are career options for their students). There is also clearly variation across STEM teachers depending on their subject and exposure to potential careers.

Careers advisors, too, had little idea of the range of engineering careers. While they had greater understanding of the tertiary pathways into engineering than other influencers, this does not necessarily translate into the reality of engineering disciplines or roles. Potential students reported that careers advisors were 'not useful at all' at helping them decide on an area for tertiary study, although they were able to present them with different qualification options.

Careers advisors also had a dim view of how well engineering was understood in New Zealand society. As one put it:

I think society in general has little understanding of engineering, in spite of the information sharing and advertising done by [tertiary education institutions]

Even among engineering employers, there was little understanding of the breadth of the industry. One participant described it as the 'hidden industry'; with few role models and little visibility. Others noted that engineering is really multiple industries with different needs. When discussing what engineering careers are like in 2014, an employer said:

I'm an engineer and I have no clue!

Tellingly, engineering employers themselves used 'engineer' to describe apprentices, technicians and professional engineers. Given the breadth and depth of the industry, as one participant said:

Is it any surprise that people don't really know what engineering involves?

3.2 Engineering is Perceived as an Unattractive Career

While there is limited understanding of engineering as a field and a career path, what understanding there is portrays engineering as an unattractive option. These assumptions are made by both potential students and influencers, which contributes to ongoing negative perceptions.

The broadness of the term engineering is no help to dispelling these assumptions. Engineering is thought to consist only of the tradesperson or the professional, each of which is subject to off-putting stereotypes.

Technical engineers are seen as working with tools and machinery, in a job that may be dirty, smelly, noisy and repetitive. This perception is subject to a high degree of snobbery from those students interested in a BE – they see technical roles as being for underachieving, 'dumb' students.

In contrast, professional engineers are seen as either wearing a hard hat or working in a cubicle, both of which are dull. Engineering is most commonly equated with civil engineering, and therefore 'boring' bridges, roads and buildings. The perception of professional engineers as introverted 'nerdy' loners is alive and well.

There is a mathematics/creativity dichotomy in the professional engineering dialogue – so many of the assumptions are predicated on engineers being mathematical and therefore not interesting or creative. One student noted:

People don't realise that engineering is design. They think its calculus.

This perception also places engineering low in the hierarchy of professional occupations. While at BE level it is definitely regarded as a profession, in most spheres engineers in New Zealand appear to have less social status than doctors or lawyers (except by those with engaged with the industry). This perception contrasts strongly with the perceived difficulty of engineering at university, detailed in Section 3.3.

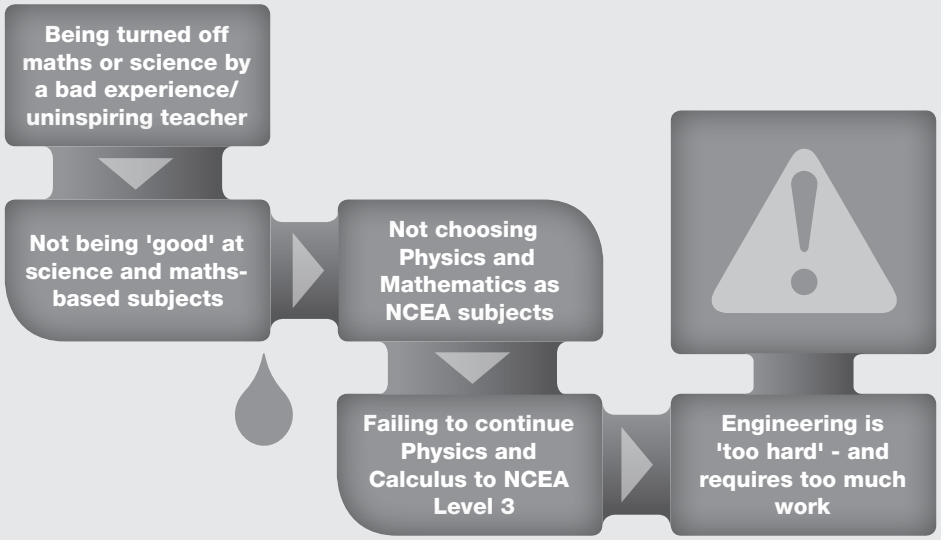
Engineering as STEM's Poor Cousin?

This lack of awareness about engineering as a career is a recurring theme in this research. Even among the students who stayed with STEM subjects until the end of secondary school, many talked about how other career pathways were 'better lit'. One told us 'architecture had very clearly defined roles and directions, whereas my understanding of engineering was far too vague'. Others talked about how a pathway into medicine, or food technology, were easy to understand and visualise. The distance to engineering was best captured by one student in this research who asked 'but what do engineers really do?'

3.3 Barriers to Entry are Perceived as High, and Erected Early

This research suggests that the metaphor of a 'leaky pipeline' can be applied to the loss of children from the potential engineering student market (Figure 3.1). There are a number of leaks in this pipeline; starting in primary school and continuing at secondary school.

3.1 The 'Leaky Pipeline' to Engineering



Students looking to study engineering at a tertiary level need to have NCEA in Physics and Calculus at Level 3. But there are a number of leak points which reduce this market considerably. Students and parents felt that it is easy for New Zealand school students to be 'turned off' science and maths at an early age, simply through one bad learning experience. Students were clear that teachers have a key role to play in nurturing or stifling interest in STEM subjects. One student said:

Teachers can inspire, but they can turn you off a subject for life too.

Students' perceptions of their ability can also lead them to narrow curriculum choices. Again, teachers and learning experiences can influence students toward seeing themselves as being good or not good in a particular area. One parent noted:

Students have lots of bad experiences with maths.

A key 'leak' occurs in secondary school, when teenagers select which subjects to study through NCEA. All those who discard physics or mathematics automatically disqualify themselves from bachelor-level engineering study. Parents, students and employers identified a number of reasons why students don't continue maths study beyond compulsory point.

Parents and employers felt that part of the problem was the way mathematics is taught at secondary school. Rather than address this directly, the general view is that maths has been turned into a narrative, with maths taught as a form of English – whereby you need to write about problems, rather than compute or solve them.

Similarly, maths teaching is seen to lack real world relevance. This makes it seem more esoteric and complex than it is – again acting as a leak point for students. Students and parents also thought this meant NCEA STEM courses do not enable independent enquiry, or nurture curiosity about STEM subjects. They felt NCEA made the STEM subjects too basic.

Participants had a tendency to attribute the problems with maths study to NCEA. That is, they criticised how NCEA study seems designed to allow the 'average student' to pass, mostly by 'teaching to the test'. One student put it succinctly:

NCEA is about getting to the answer, and not the concepts behind the answer.

This belief, and a lack of knowledge about what makes a good engineer, is creating another leak point. One Auckland mother was concerned that despite his ability in physics, her son did not have the maths skills to study engineering (he now plans to study physics at university). She said:

I was not really happy about him doing engineering as I felt his maths was not as good as is necessary. I was worried that he would have to drop out half way through his first year due to not being able to keep up with the work due to his weakness in maths.

International students argued that STEM subjects are comparatively easy at New Zealand schools. They also thought New Zealand students tended to look for easy options rather than put in the hard work to master concepts.

Parents, students and teachers have an inherent belief in the need for good NCEA marks in science and mathematics to study engineering. At the end of Year 13, this is a much-reduced market – those who have carried through with both Physics and Calculus to NCEA Level 3, and are achieving at a high level.

A similar leak point is the perception of engineering study, which leads some students to put it in the 'too-hard' basket. University–level engineering study is seen as difficult by both potential students, teachers, and parents – they are clear that study requires hard work, discipline and commitment. Engineering programmes have high entry requirements, limited admission, and involve a large amount of work. One student put it simply:

[Engineering] is the second hardest degree in New Zealand… it's a massive course load compared to a Bachelor of Arts.

However, most engineering students are proud of this need for hard work; it helps create the perception that engineering students are the 'best, smartest' students.

The culmination of these leaks is that the market for tertiary engineering study is much reduced. More importantly, those remaining are intelligent, hardworking, and convinced of the superiority of the BE. These factors mean they are unlikely to make good BEngTech students. This is elaborated upon in Section 4.3

NCEA Technology is Another Barrier to Entry

While technology classes at secondary school seem like a natural part of the engineering pipeline, in reality it creates more barriers to tertiary engineering study. While the class may be intended for those interested in degree level engineering, it is not seen this way by students or parents. Additionally, the assessment by unit standards makes the class unattractive as university preparation; simply because they lower students' GPAs by precluding the possibility for merit and excellence achievement.

Conversely, technology teachers believe their less-academic students are not capable of some of the advanced concepts in the class, simply because they may not have the maths or English skills to complete the work. A potential student described how his Technology course attracted 'slow' students, and how the course then had to be taught slowly so they could keep up – which made the class boring for the bright students. One teacher simply said:

Technology is a dumping ground for the unachievers.

3.4 Engineering Careers Have Few Champions

The research is clear that potential students are mostly drawn to engineering by familiarity, through family or family friends who are engineers. These students have grown up with engineering as an option, which does not seem to be the case for most students. Family and friends are obviously the major champion for engineering among young people, and there are few others.

This view of the importance of a family connection is widespread. One senior academic involved in student recruitment said:

The truism around here is that those most likely to study engineering already have a parent who is an engineer.

This was reinforced by a careers advisor who said:

Students showing an interest in engineering usually have links or connections with engineering through family or friends.

In some cases, key teachers may have had an influence. Overall, however, students reported a lack of encouragement by teachers and careers advisors. One Hamilton student said:

School never interested me in [engineering] at all…I just found [engineering] interesting.

Another agreed:

Engineering is invisible at secondary school.

A secondary school STEM teacher made the same point when she told the researchers:

Engineering was never actively promoted through our department… subjects like medicine had a much higher profile.

Students agreed that a good teacher had the ability to inspire them to a career in engineering, or at least open them to the possibility. One student said:

I had a really good physics teacher and [that] shaped my interest in physics.

An Auckland student credited his interest in engineering to his school, saying:

At our school if you were good at physics and maths then they really pushed you into engineering.

Some thought that teachers did not encourage students into engineering because they didn't properly understand the value of engineering. They also felt that teachers had little understanding of the jobs available in the industry (and the current shortage).

It is evident that there are few well-known engineering role models (if any). In fact these students, all of whom were going to study engineering or had an interest in engineering, could not name a single famous engineer. Participants indeed doubted that there any famous engineers. One Hamilton student said:

I don't think there are any famous engineers anywhere…are there any?

Another noted:

I don't look at a bridge and think who built that?

Parents and employers agreed that there are no role models for budding engineers, in contrast to other professions. They cited popular television shows and celebrities as influences on other career choices.

3.5 The Gendered Nature of Engineering Reduces the Market Considerably

There is considerable international literature on the gender imbalance in STEM disciplines. This is a widespread problem, both internationally and domestically - in New Zealand, just 13% of engineers are female[3]. Gender roles run deep and there is evidence that gender bias in engineering is systemic and ongoing, and will need a co-ordinated response.

Male potential students in the research demonstrated this gender bias. One said:

In my household, I've grown up with males fixing stuff, and you see engineering as fixing stuff. In my house, if something's broken, no-one would be, like, Mum can you fix this?

A male mature student said:

I once walked into a classroom and there was a girl there so I walked out, because I thought I was in the wrong room.

The research emphasised some obvious areas where women are specifically turned off engineering study. These included:

- The perception of engineering as a 'physical' career that girls and women are not as suited to. This is perhaps a greater influence at the technical level of engineering rather than the professional level, where tool use is more important to jobs;
- The gendered nature of engineering may be self-perpetuating to a degree: some female potential students researched were put off by the idea of male-dominated workplace culture;
- Participants thought that engineering is not promoted to girls as a career, even for those with an interest in science and maths. High-achieving female students with an interest in STEM were generally encouraged to enter other disciplines, primarily medicine or health sciences;
- Teachers in primary and secondary schools are overwhelming female.

It must be acknowledged that IPENZ, Women In Engineering (WIE) and other engineering organisations have ongoing efforts dedicated to increasing the popularity of engineering careers among girls and women. Given the international emphasis on promoting engineering to women, it will be important for interested parties to remain up to date on international initiatives and the examples they offer for the New Zealand context.

3. IPENZ, Attracting and Retaining Women in Engineering, http://www.ipenz.org.nz/IPENZ/Career_development/Attracting_and_Retaining_Women_in_Engineering.cfm

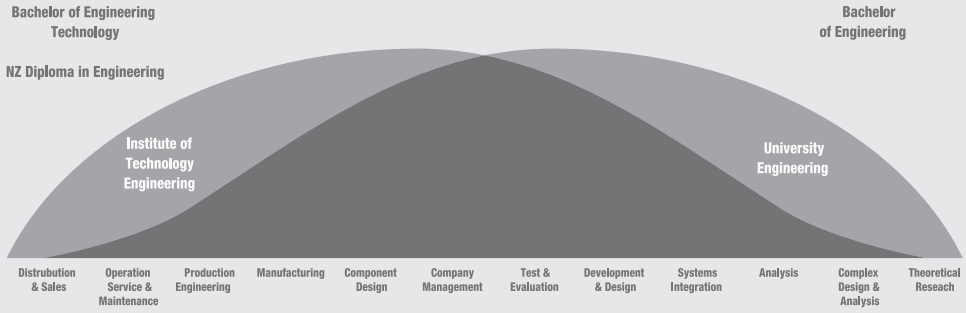
4 Why Aren't Potential Engineers Interested in a BEngTech?

4.1 The Technologist Role is Poorly Understood

To compound the limited understanding of engineering among New Zealanders, there is an even more limited understanding of what is meant by 'engineering technologist'. This lack of knowledge is prevalent among students with an interest in engineering, teachers and careers advisors, parents, and even employers.

This research has already detailed the lack of understanding of engineering careers in general, and the perceived dichotomy of technicians and professionals (see Sections 3.1 and 3.2). This emphasises that roles in the middle ground – technologist roles – are unseen by most potential students. The option is not articulated by teachers or careers advisors, and therefore is not known by potential students.

4.1 Where Engineering Technologists Fit In



As noted, students are often influenced into engineering through their family or family friends. These influencers tend to present the limited view of engineering they themselves know. That is, children of professional engineers may be more interested in professional engineering, and likewise for children of engineering technicians. This reiterates that potential engineering students have little understanding of other engineering career paths, such as the technologist role.

Parents in general were unaware of pathways into engineering, other than the BE or what they had taken. In general, the career path into para-professional engineering roles was very poorly understood. Many of these parents would prefer their children did an apprenticeship and got applied skills and experience if they don't make the BE programme.

Employers also displayed little knowledge of the technologist roles, despite the apparent need for technologists in the marketplace. Smaller, workshop-style engineering practices were more interested in technicians than in technologists. They felt that they often did not have enough work for a degree-qualified engineer, and preferred to contract any design work. This part of the industry is experiencing real skill shortages and reported importation of Chinese labour, but still had little understanding of how a technologist would fit into their workforces. One employer said:

[The BEngTech] is for modern technology companies… not old fashioned engineering.

In contrast, larger firms, often identified by IPENZ as the real market for technologists[4], felt that the BE was clearly superior to the BEngTech. These companies tend to use BE graduates in their technologist roles, increasing the complexity of their work as they gain more experience. One HR advisor at a large engineering practice said:

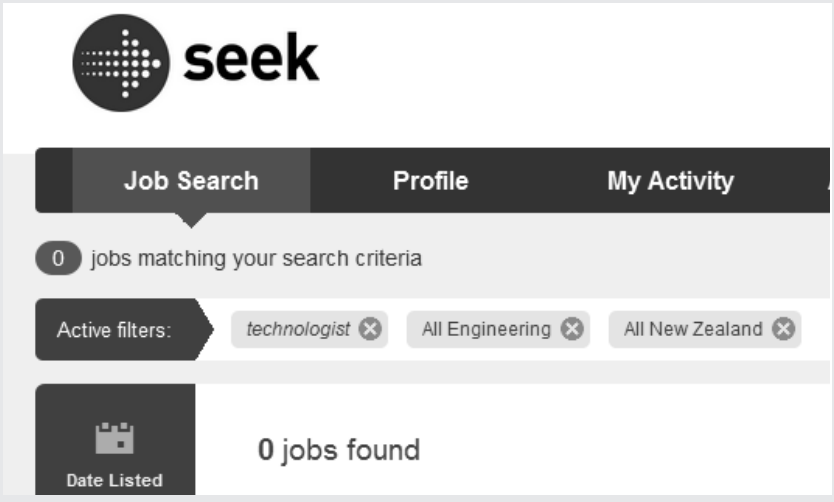
BEs are a no-brainer for us.

One employer was clear:

What ends up happening is that we get the more junior engineers [i.e., BE graduates] to do a mix of engineering and technician work, with the latter diminishing as they get more senior.

During this research, a search on seek.co.nz for 'technologist' in the engineering category revealed zero jobs[5]. While the roles may exist, the language used by employers clearly does not match up to the language of the qualification.

4.2 The Invisibility of Technologist Roles in Engineering



It is clear that to encourage students into the BEngTech, there first needs to be greater understanding of the role technologists play in modern engineering disciplines. There also needs to be promotion of the rise of para-professionals in engineering, and the national need for technologists.

4. IPENZ, The Demand for and Supply of Engineers.

5. Search made on September 30th, 2014: http://www.seek.co.nz/jobs-in-engineering/in-new-zealand/#dateRange=999&workType=0&industry=1209&occupation=&graduateSearch=false&salaryFrom=0&salaryTo=999999&salaryType=annual&advertiserID=&advertiserGroup=&keywords=technologist&page=1&displaySuburb=&seoSuburb=&isAreaUnspecified=false&location=&area=&nation=3001&sortMode=KeywordRelevance&searchFrom=quick&searchType=

4.2 ITPs are Heavily Associated with the NZDE Pathway

Both potential students and influencers were aware of two main pathways into engineering: the professional route (BE) and the technical route (NZCE/NZDE). This led to the understanding that the degree would be gained at a university, and the certificate or diploma at an ITP or through an apprenticeship (although the apprenticeship route was less favourable).

There is little room in this schema for the BEngTech. As ITPs are associated with providing the technical level of education, they are precluded from offering a degree or indeed any more academic qualification.

Parents, in particular, have limited knowledge of the ITP offering. Parent perception of ITPs is a strong barrier to students' perceptions of ITPs. In one case, parents did not realise that ITPs offer an engineering degree – they assumed this would be a certificate or diploma. These parents wouldn't encourage their bright, engineering-inclined children toward ITP degrees if they were more academically disposed.

Note that employers acknowledged that ITPs are already doing a fine job of training. A number of employers in this research were enthusiastic about ITP graduates they employed. They felt that an ITP qualification was the perfect training for a range of vocational, practical positions (rather than professional positions). One employer said:

The [polytech grads] we've had in the past have been excellent.

4.3 ITPs are Not Universities

There is clear evidence that potential professional engineering students are biased against ITPs. While this might seem an obvious market to convert to BEngTech students, their esteem of the BE militates against this. One physics teacher said:

I get the ones intending to go to university. They don't even consider other schools.

Another teacher agreed, saying:

There is a group mentality from kids, and sometimes parents, that university is best.

In the minds of these students, universities not only have a better reputation (particularly the University of Auckland and University of Canterbury), university is the option for smart students. ITPs, on the other hand, are considered the pathways for the 'less academic' students. The assumption here is that polytech engineering students are simply "not smart enough for uni". One Hamilton student said:

People judge you if you don't go to Uni. If there were 2 guys at my school doing Engineering and one was going to [an ITP] and one was going to Uni, people would definitely think the one at Uni had more brains.

An Auckland mother exemplified this perspective when she said:

We thought that because [our son] was exceptionally bright we should encourage him towards the university rather than the practical trades route. His father is a tradesman gas fitter and though he has been around this all his life he is more interested in the academic side of engineering and design.

Another Auckland parent, also a civil engineer, said:

I feel it would definitely be best for my daughter to go to university rather than a polytechnic. It is best to get a Masters degree in engineering and that can only be done at a university.

And a Hamilton parent put it succinctly when they said:

If in doubt, and your kid is bright enough, tell them to go to a university.

An employer also made this distinction crystal clear:

There are significant differences in the ability in core engineering disciplines between university grads and polytech grads.

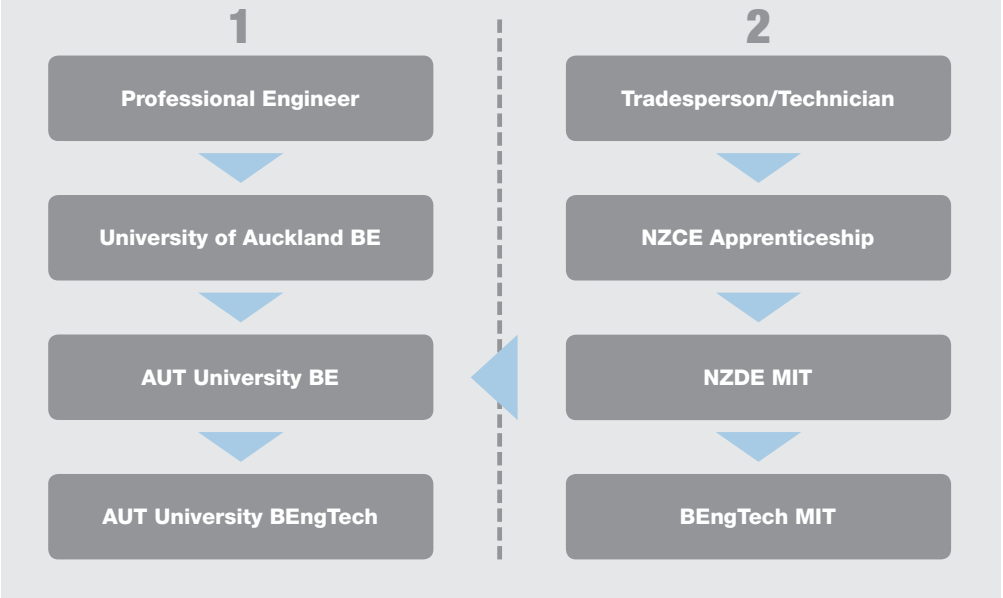
Adding to this perspective is the view that an engineering degree at an ITP would be more hands-on and practical, and therefore more closely related to a diploma or apprenticeship. In contrast, university was preferred by some students because of its more heavily theoretical focus. University engineering also combines principles of a commerce degree, like management and business. As one potential student said:

Engineering [at an ITP] is a bit more hands on, like putting together stuff, and engineering at uni would be like planning and organising the engineering that the trade engineers do.

Also important in decision making is the role of campus life and student experience. Some students noted that they would choose university even if the university and ITP degrees were identical, simply because the university would also have a better student experience. This perspective was common – when potential students acknowledged that they might not get into the engineering programme at the University of Auckland or University of Canterbury, they thought they would just study something else at university (rather than attempt a BEngTech at an ITP).

Importantly, not all universities are equal. Potential students displayed a marked preference for the University of Auckland, followed by the University of Canterbury. These two programmes were simply seen as 'better', compared to other BE programmes. For example, the BE at AUT University was clearly seen as lower quality – despite the provisions of the Washington Accord. This is because the Accord is seen as providing a minimum standard of education.

4.3 Choice Hierarchies by Engineering Type



4.4 'Easier' is Not Better

Potential students agreed that engineering study at an ITP would be easier than study at a university. This perception seemed to stem from their esteem of the BE degree, as well as their preference for universities in general. One student described who an ITP BEngTech could appeal to:

The people who aren't as academically inclined, but still reasonably skilled and aren't getting excellences in calculus and don't think they are good enough for engineering.

This emphasises that the ITP degree was seen as easier, but of lower quality. The BEngTech would therefore lead to a lower skill area of engineering than the BE. One student reiterated this perspective, when they said of the BE:

What's one more year of study for a better quality degree that will get you started higher up the ladder?

Some students pointed out that there are lower entry criteria for the ITP BEngTech than the university BE. They saw this as indicating that the BEngTech was for 'less academic' students, who might not be able to make it in the BE programme.

Mature students in Auckland felt that the difference between a BE and a BEngTech was more about the quality of the students than the quality of the programmes. They thought the BEngTech was necessarily easier, because it was aimed more at technicians than an engineers.

4.5 The Providers Compete and Don't Collaborate

This research highlights the need for an ecosystem wide response to encourage more students into engineering (see Section 6). Such an approach needs to be built on collaboration. Currently the tertiary education model is built on competition which works against genuine collaboration. This is seen most obviously in the way students with an interest in engineering are often lost to the industry because they became captured by the institution. For instance students who fail to complete their first year of engineering, ostensibly a market for BEngTech, are instead channelled by universities into science or ICT programmes. In Blenheim, teachers felt that the local ITP competed for their secondary school students. There are few examples of relationships between different groups in the engineering ecosystem, and little evidence of the sectors working together with industries.

4.6 There are Regional Differences

Location is a widely-regarded key factor in choice of study provider. It is also a factor in choice of study provider for engineering.

For example, in Auckland. A BE at the University of Auckland is a clear first choice for potential students. The offering of a 'lower' BE at AUT University means that students dropping out of the first year BE programme at University of Auckland choose to complete this lower BE rather than a BEngTech. The size of the location means they have more options, and less direction toward the BEngTech as a back-up qualification.

In Nelson and Marlborough, participants had less idea of the options available to them in engineering careers. Smaller regional centres are less exposed to the potential of engineering, and therefore may be less engaged with engineering as a career choice. Participants also felt that students tended to want to leave regional centres for study, and the 'get out of town card' was usually presented as university.

Potential students in Nelson were drawn to the international relevancy of the four-year BE (through the Washington Accord). There is clearly little knowledge of the Sydney Accord, and how it establishes the international relevancy of the BEngTech.

5 How to Make the BEngTEch More Attractive: The Marketing Response

5.1 Marketing the BEngTech

The analysis presented in Sections 3 and 4 demonstrates that the challenges facing ITPs in making the BEngTech more attractive are systemic and deep-seated. The response suggested by this research is two-fold. The first addresses how the BEngTech qualification is marketed, and the second (more fundamental response) addresses the assumptions behind the BEngTech itself. This section addresses the maketing response. This response is addressed first because it provides a more immediate (and more tactical, less strategic) way to move towards the E2E goal of student growth in 2017.

The challenge for those marketing the BEngTech is three-fold. That is, the marketing of the qualification needs to address:

1. How to generate greater interest in engineering as a career.
2. How to convert this interest into study intentions.
3. How to position the ITP as a preference within these study intentions.

Given the challenges identified in Sections 3 and 4 of this report, it is clear that for each of these three purposes the marketing response needs to work through each step in the the classic 'engagement cascade' (Figure 5.1).

5.1 Engagement Cascade

5.2 Make Engineering as a Career More Attractive

The first challenge is to make engineering as a career more attractive. This means addressing issues of awareness and knowledge of the career before moving to shape attitudes and preferences for it. Participants from all groups in the perception ecosystem felt strongly that engineering in general needs to be made more attractive. Repositioning engineering should focus on six major areas:

- Distinguish the different meanings of 'engineer'. Make it clear that there are middle-ground career paths, and engineers can take a wide range of roles in the employment market;
- Emphasise the need for problem-solving and creative thinking. Engineering is about innovation and invention, and technologists could be involved in the testing and refinement of new technology. Engineering is not just a pathway for the mathematically-inclined, it is also a creative outlet[6];
- Show how engineering is the instrument of social change and connect it to real world applications. Some students were drawn to engineering because it is shaping the real world around them. Marketing initiatives could emphasise this aspect of engineering. Engineering also has applications for improving quality of life, both in New Zealand and internationally, which could be emphasised (see Engineers Without Borders for one example);
- Use role models. While these may be of limited effectiveness in influencing students to choose engineering, they could help present the pathway. Parents felt that popular role models were most effective at shaping students' career aspirations;
- Connect with industry and demonstrate employment possibilities. Engineering offers high rates of graduate employment and there are demonstrable shortages. Use industry to show students the work they could do as a graduate BEngTech – this may also help to dispel assumptions about how unattractive engineering is. Employers suggested that marketing could be clear about where the jobs "really are"; and
- Focus on the international relevance of New Zealand qualifications. Potential BE students were attracted by relevance through the Washington Accord. Emphasise that the Sydney Accord provides similar opportunities for engineering technologists.

Overall, participants made an important point about experiencing engineering rather than being told about engineering. Initiatives they regard as most successful involve students having an experience - not simply being presented with information. Suggestions included a travelling roadshow with practical experiments, or opening up universities and ITPs for potential students to 'have a play'.

6. One way to strongly signal this would be to move beyond maths and physics as the only prerequisites for engineering – the BEngTech could also require a creative subject such as art or design

5.3 Build on Current Successes

There are a number of initiatives in the market that seem to be working to raise interest in engineering as a career. Participants in the focus groups detailed some initiatives that they thought were successful in attracting students to engineering. Some are already ITP-based; others could be adopted by ITPs.

Examples of successful initiatives included:

- 'Get a Life' careers month[7] (run by Wintec, Connexis & WECA). This exposes secondary students to what a career in engineering would involve. It is very highly regarded by employers;
- Wintec's Trades Academy[8] exposes some secondary school students to trades training that can staircase into a career in engineering;
- CPIT Kidstech (run as part of TV2 Kidsfest). This is a day programme run during school holidays for children and their caregivers to experience CPIT's engineering department. This is highly regarded by parents and perceived as influential on children's career choices;
- Massey University's Engineering Your Future Camp[9]. This is a four day learning camp run by Massey University, designed for Year 11 – 13 students. Students credited this with fostering their interest in engineering, and making them 'realise engineering is about problem solving.' This could be redesigned into a holiday programme for younger students; and
- The Futureintech Ambassador programme run by IPENZ and Callaghan Innovation.

Notably, current initiatives are atomised – to make them more effective, these need to be networked. To make these most effective, the involved parties should attempt to reproduce them in different regions.

5.4 Start Early

Secondary school students appear to be encouraged to start considering their future career direction in Year 10, when subject options become much more varied (and students begin to limit their options for tertiary study by excluding pre requisites). This is a critical time to work to keep students engaged with STEM subjects.

Equally, to expand interest in STEM subjects (rather than obligation), children need to be exposed to and involved in engineering at a much younger age. Participants in this research were clear that children have preconceived ideas about what to do from an early age, and there should be initiatives targeting, focusing and supporting

7. http://www.getalifewaikato.co.nz/
8. http://www.wintec.ac.nz/wta/Pages/index.aspx
9. http://www.massey.ac.nz/massey/learning/colleges/college-of-sciences/about/engineering-technology/engineering-your-future-camp--sign-up-here.cfm

children towards engineering from primary school. They also felt that current interventions start too late to be properly effective.

This means early exposure to the possibility of engineering, and then nurturing of that interest. Students suggested that Lego-based problem solving and creating things at school could be a way to capture more interest in engineering. Employers thought that 3D printing would also offer opportunities to attract students' interest. One parent said:

New Zealand doesn't have a culture that recognises engineers… We should create a culture where all students are exposed to engineering at preschool/primary school.

It is important for parents to come on board and support this interest at an early age. Parental encouragement is demonstrably important to children's interest in engineering; ideally, children without a family member or other influencer would experience the same level of encouragement to engineering as those with.

5.5 Enrol the Schools

Participants expressed a desire for the education system to 'fix' maths teaching – that is, lessen the frequency of poor learning experiences and find a way to make it more engaging. Teachers noted that particular work should be done during intermediate years, when students tend to become less interested in STEM subjects. One way to link maths teaching with engineering could be to emphasise the problem-solving aspects. Maths teaching may also need some more real-world applications, as students felt it was most interesting when concepts could be applied to real world situations.

While some participants felt that NCEA maths should be made easier, overall the research discounts this approach. First year university engineering students already have difficulty with the transition between NCEA Level 3 Calculus and university-level Calculus; they felt that NCEA Calculus should become harder to more adequately prepare them.

Similarly, some participants detailed improvements that could be made to science teaching. They felt that practical experiments were the easiest way to engage students in science. As one parent said:

You can also start by adding some theatre. Good science teachers know how to do this already. Blow stuff up, flashes and bangs, surprise the kids.

Another possible response to the lessening interest in STEM is to make subjects compulsory through to Year 13. This would automatically widen the market for potential engineering students, as more students would have physics and calculus to the required level.

What To Do About Maths?

There are two distinct view about maths in this research. The first is to 'fix' how maths is taught to engage more students for longer (perhaps by making it compulsory). International students were particularly supportive of this compulsion-and-fix approach. The second is to say that maths is an insurmountable barrier and the way forward is to reduce (significantly) the maths entry requirement to engineering. This argues the view that ability in maths is no longer a good proxy for ability as an engineer. And nor do real-world engineers need to know how to compute maths, but simply how to apply the computations.

5.6 Use Industry to Educate the Educators

This research has identified a need to educate teachers in STEM disciplines and careers advisors about both engineering in general, and the pathways available through BEngTech study. The key here is for this 'education' to focus on the potential of the industry and of the polytech pathway. For educators to disseminate the information, they must be aware of it themselves and generally regard it as a valid option for some of their students. One employer simply said:

Engineering needs more champions in schools.

Caution is needed here; teachers and careers advisors clearly do not want to 'push' their students into a career pathway. Rather, they see themselves as presenting students with options for future careers.

Generally, teachers had varying levels of involvement with the dissemination of careers information. Some were very engaged with directing their students' interest, while others had little idea about the current job market and therefore little idea about potential careers. Teachers did note that their official role did not include giving careers advice and they received little recognition for helping students with this. Rather, recognition was based on their students' achievement levels. One teacher said:

I don't get any kudos for turning out well advised students as far as their careers go.

Teachers also identified the need for funding for such career initiatives. They did not receive any extra support for career advice, and would need funding to be able to expose students to extra-curricular activities that would spark their interest in engineer. One teacher noted:

I'd be happy to take 10 kids to [an ITP] and show them the engineering facilities down there…. but… at the end of the day, that's tied to the school and it's a relatively high cost.

Teachers and careers advisors indicated that the best way for industry and ITPs to connect with them is face-to-face. This would be a large undertaking but examples such as the Technology Education Subject Associations Coalition (TESAC) and Weltec workshop, which brought Technology teachers to a presentation at Weltec facilities[10], are a positive example. Connections between ITPs and secondary education could focus on relationship building, to be most effective.

5.7 Make a Special Effort with Girls and Women

Perhaps the easiest way to increase the market for engineering students in general (and for ITPs in particular) is to make a special effort to recruit female students to the subject. While gains have been made in recent years, IPENZ is clear that projected demand for engineers could be met if participation rates among female students were raised to those for male students[11]. This issue was brought into stark relief in this research during discussion with students and graduates who had completed their secondary school education overseas. As one put it:

The gender issue was invisible [in Singapore], and the idea that women did not do as well in maths or sciences [as men] was a notion I only encountered when I got [to New Zealand].

And

My school [in Singapore] did not discourage girls from professions 'cos of some inane notion of gender.

Contrast this to recent local experience. One graduate told us, while describing how no-one had discussed a career in engineering with her at secondary school:

Can you believe it? The only girl in a sea of boys [in STEM classes at secondary school], you'd have thought someone in the STEM curriculum would present some possibilities to me but in fact it was my dad.

Other graduates told us that despite taking STEM subjects and getting good grades:

No-one talked to me about science as a career, and I would have had no idea what an engineer was or did.

Another STEM graduate said:

I don't remember it being discussed as a potential option.

10. http://www.techlink.org.nz/stories.cfm?area=10&SID=184

11. A similar argument can be made for focusing special efforts on increasing the participation of Maori and Pasifika students in engineering.

One graduate who was both good at STEM and interested in engineering recalls:

I was told to do something like be a surgeon or a lawyer [but] I think I would have enjoyed doing engineering.

Even at those schools where 'bright' female students are actively encouraged into STEM subjects, there is little encouragement to pursue engineering. Instead, other science-based careers are promoted as being a better fit for female students (such as medicine, lab work, food technology, etc.). This is supported by the Ministry of Women's Affairs own research (2012) which found that women were less likely than men to know about engineering as a career option, and that women in engineering were often motivated by a teacher who had demonstrated how they could 'make a difference through engineering'. There is an interesting parallel here with the work Research First did for MWA about women's participation of the rebuilding of Christchurch, which found that women saw construction jobs as 'jobs for men' and, instructively, interpreted the ads for such jobs as being 'aimed at men' (MWA, 2013[12]).

One approach which this research did uncover was the potential for use of female role models. While generally role models are of uncertain effectiveness in encouraging students to study engineering, they may be more use with women in simply opening up the path for study.

One solution might be to offer single sex education engineering classes. Another might be to re-frame how engineering is presented and taught. There is evidence that the 'environmental cues' currently in place in traditional science classes discourage females' interest and engagement. Similarly, having more female teachers and tutors in engineering at secondary and tertiary education is likely to improve interest and engagement.

Interestingly, one school in the research was looking at beginning female-only STEM classes, to help encourage girls into STEM classes. This approach was borrowed from the Wintec Trades Academy, where it has been anecdotally successful.

5.8 Price Could be a Factor

Some students suggested that the BEngTech would be attractive because it was cheaper and shorter than a BE. These aspects could be emphasised in marketing; however caution would be needed, as too much emphasis could devalue the qualification and alienate those students who are interested in a BE.

12. Ministry of Women's Affairs (2013) *Building Back Better: Utilising Women's Labour in the Canterbury Recovery*. Wellington, Augusts 2013.

6 How to Make the BEngTEch More Attractive: The Product Development Response

6.1 Reimagining the BEngTech

The second way to make the BEngTEch more attractive is to reimagine the qualification. In other words, to re-examine the assumptions that have shaped the BEngTech in its current form. This recommendation starts from the clear implication in this research the BEngTech (as currently configured) may be at odds with what the market seeks.

This research suggests that a Bachelors qualification aimed at 'technologist' roles makes assumptions about both supply and demand that may not bear scrutiny.

Instead, this research suggests that a Graduate Diploma in Engineering Technology could be a better fit with both industry and students. Note that this is how engineering technologists are catered to by other signatories to the Sydney Accord, notably South Africa[12].

This makes sense because the largest market for this kind of qualification is likely to be among engineering technicians who are looking to advance their careers. This research is clear that ITPs are likely to get better success selling BEngTech (or equivalent) pathways to NZDE graduates looking to upskill than they are to capture BE students who fail to make the grade.

Note that this has considerable implications for how the qualification is conceptualised and delivered, as this market is likely to be in employment and needing to fit study around work (and not attend fulltime).

Reimagining the BEngTech as a graduate diploma may also make the qualification attractive to BSc graduates looking to add an applied focus (and an employment pathway) to their degree. This research is clear that ITPs should not attempt to market their Level 7 qualifications to students in the current BE market. In that market the BEngTech is seen as a poor second choice (or third choice in the case of Auckland BE students). But students with BScs present a larger, and largely untapped, market. These students already have an interest in STEM subjects and are likely to be eager to find applications for their degrees. Moreover, they will have had their 'university experience' and will be looking to make the transition into the adult world of work.

12. https://www.ecsa.co.za/about/pdfs/List_of_AccrBTech_E-20_PT_2012.pdf

6.2 Collaboration and Competition

If we are serious about meeting the needs of the engineering sector in New Zealand then there needs to be an effective way of putting the sectors' needs before those of the providers. Currently the model rewards competition over collaboration, which means that students are more likely to be captured by an institution than challenged into the most appropriate education pathway. Equally, there is little sector-wide collaboration between schools, careers, tertiary education, and industry.

From the perspective of this research, the 'careers pipeline' into engineering appears to be broken (or at least severely stressed). What really seems to be needed is a thoroughgoing and sector wide co-ordinated response.

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