

CREATING ENGINEERS

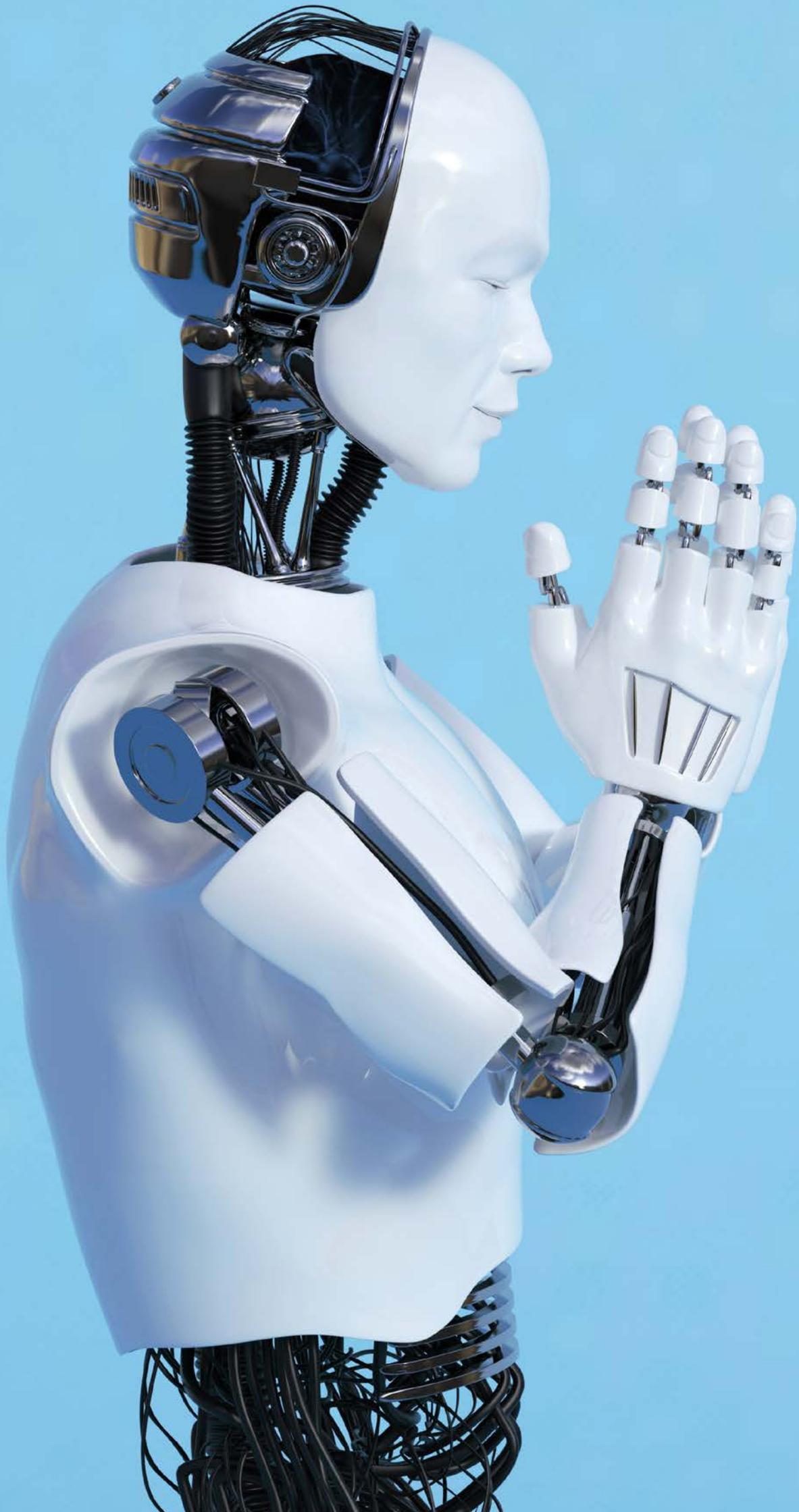
CLIMBING THE EDUCATIONAL STAIR-CASE

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THE ENGINE
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ACKNOWLEDGEMENTS

We wish to thank the following people who generously gave their time and/or valuable insights: Jeremy Hill, David Pearce, Peter O'Byrne, Andrew Campbell, Russell McMullan, Graeme Milne, Chris Nightingale, Murray McNae, Nick Evans, Stuart Gebbie, Richard Templer, Andrew Cleland, Tim O'Connor, Vanessa Pitt, Anne Frater, Aaron Steele, Bill Darnell, Don Cleland, Don Burns, Karsten Zegwaard and Kahu Cracknell; also participants in the Metro ITP executive group meeting (Oct 1): Max Kerr, Mark Flowers, Chris Gosling, Kay Giles, Matt Carter, Rick Ede and Charles Finney.

LIMITATIONS

This report is a 'snapshot' based on the responses of 28 stakeholders. Our recommendations are formed from a synthesis of these responses. While those stakeholders are individually qualified to offer expert opinion, some sub-sectors within the engineering education system were represented by relatively small samples, and therefore results should be treated as indicative.



Tertiary Education Commission
Te Amorangi Mātauranga Matua

Introduction

Following research into degree apprenticeships as a mechanism for increasing the number of level six and seven engineering graduates in New Zealand (Goodyer & Frater, 2015), Massey University School of Engineering and Advanced Technology (SEAT) was further invited by TEC to examine ‘stair-casing and pathways’¹ as viable strategies and mechanisms for progression into, or within, engineering careers.

Method

Our methodology involved extending the literature review that was conducted in the previous research, focussing more specifically on educational transitions. We also considered the roles of graduates at various levels and industry requirements for employees in those roles. For our empirical research component, in order to obtain a balanced and representative sample of relevant viewpoints, we conducted interviews with a wide range of stakeholders including: tertiary level academics and managers; executives from industries employing engineers; industrial and engineering research organisations; and secondary and primary school managers. We also incorporated opinions expressed during a meeting of the ‘Metro ITP’² executive group, during which the conclusions of the previous research report were discussed. Appendix A provides a summary of the respondents interviewed during the course of this study.

Our research method took the form of face-to-face interviews plus telephone and Skype interviews. In these interviews we introduced the terms of reference of our research, and sought ‘unguided’ perspectives within the context of each stakeholder. Ideas and opinions related to the terms of reference that had been expressed by previous interviewees were introduced into our conversations to generate a progressive discussion with balanced opinions. To preserve respondents’ anonymity, respondents are identified only by their respondent number in the text that follows: for example [R1] refers to respondent(s) 1 from Appendix A.

Executive summary

Following research into degree apprenticeships as a mechanism for increasing the number of level six and seven engineering graduates in New Zealand, this report investigates whether stair-casing has the potential to provide viable strategies and mechanisms for students progressing into or within engineering careers based on the literature and interviews of key stakeholders.

In the context of this report, stair-casing described the transition via bridging courses designed to supplement normal progression from school to tertiary study. The metaphor of stair-casing describes mechanisms for enabling students to progress through a series of steps³. The critical steps are those that occur between stages that are managed or owned by distinct organisation types. In New Zealand, those principal organisational types are i) primary and intermediate schools ii) secondary schools iii) polytechnics and iv) universities.

The view of stair-casing that we gained from our interviews is that it is a crucial mechanism for maximising the potential of people who have missed the progression from school to tertiary studies, or who wish to enrol in IT/engineering subjects but who haven’t achieved the prerequisite qualifications. Existing stair-casing options described to us appear to be well-designed and effective in terms of increasing graduate numbers and their subsequent employment. However, stair-casing mechanisms are resource-demanding and mainly constitute a remediation strategy addressing the recovery of potential that in many cases could have been recognised and targeted earlier. Stair-casing mechanisms also depend on awareness of employer needs for specific graduate types and confidence on the part of students that they can achieve the end qualification when, in many cases, they have already failed to achieve in the education system.

¹ ‘Stair-casing and pathways’ is a term used to describe structural mechanisms in education systems that enable students to progress to higher levels of learning, typically at the tertiary level.

² The Metro ITP group is a coalition of New Zealand’s six largest institutes of technology or polytechnics.

³ Where defined agreements are specified (in organisational regulations) by which a student can progress from one level to another for specific qualifications (if they achieve agreed standards), those progressions are said to be ‘articulated’. The levels referred to here are the NZQA levels.

Our investigation further led us to the conclusion that there are critical issues underlying the need for and effectiveness of 'stair-casing and pathways'. These issues relate to the realisation that the provision of engineers as a critical resource for industry should be treated as a supply chain. Therefore our analysis and recommendations extend beyond 'stair-casing and pathways' to the whole system, interpreted through the supply-chain 'lens'.

1. The critical issues that we have identified are:
2. Lack of structured communication and feedback between supply chain actors.
3. Issues in the teaching of primary school maths, leading to insufficient numbers of students qualifying in higher maths and physics at year 13.
4. Early disengagement of young people with maths and science.
5. Misperception of engineering career paths.

Our key recommendations address these issues through a structural intervention to address communication and feedback (regional education hubs) plus specific recommendations with respect to rejuvenating the early 2000s 'Numeracy Project'. Other recommendations relate to student learning styles, the visibility and awareness of the full range of engineering career paths and the special case of computer engineering.

Summary of recommendations:

1. Form regional engineering education hubs including representatives from primary (and intermediate) schools, secondary schools, polytechnics, university and employers
2. Instigate new programme of teacher training for the numeracy project and develop new teacher support material for the numeracy project.
3. Reverse devolved responsibility for teacher training in maths and science from schools back to MOE.
4. Utilise current thinking around student learning styles and intelligences to identify students with aptitude for engineering before year 9 and develop programmes that exploit learning style theory to prepare and motivate students to continue studying prerequisite engineering subjects.
5. Identify and define a set of marketable career paths within engineering.
6. Further develop vocational pathways to all levels of tertiary engineering qualification.
7. Design and articulate an NZDE/BEngTech to Master of Engineering Management pathway.
8. Scholarships, linked to tax benefit or employer subsidy to be made available for employees to upskill to NZDE or BEngTech.
9. The social competence of IT students should be recognised as an essential component of all tertiary IT courses.

Background

Historical

We were provided [R14] with a personal view of how the tertiary engineering education system used to work. The respondent explained that in the post-WWII decades the development of engineering careers was fostered and enabled by large government departments such as the Ministry of Works, Railways and the Post Office. A typical career path began out as a cadetship (e.g. draughting) and progressed to the New Zealand Certificate of Engineering (NZCE). After a period of work a bursary was provided to undertake a university degree. Graduates were bonded to work for a period, but received the benefit of secure employment. There is a lot of merit in this straightforward pathway where all the stakeholders derived benefit. There was no suggestion that the professional engineers whose career began with a vocational pathway were anything other than highly competent and capable.

Organisation types and graduate characteristics

The overall picture we have gained of the disposition of engineering graduates in industry is of at least three distinctly different organisational environments needing different graduate characteristics:

MEDIUM TO LARGE ORGANISATIONS

Medium to larger organisations were found to value NZQA level 8 (e.g. BEHons) graduates highly. Their new employees are given a range of tasks including some hands-on engineering work that might be regarded as the normal responsibility of level 7 graduates in a more tightly differentiated work culture (such as would be found in Europe and the UK). Respondents [e.g. R1] value financial literacy as well as competence in higher maths and physics, and desire employees who can work in the entire design-to-build space. They also value the relative maturity of students who have spent at least four years at university.

“For the engineering side of the business, anything less than a good level engineering degree is inadequate.” [R3]

Graduate employees are generally quite comfortable with, and even appreciate, the level of variety offered by larger employers [R1]. Despite the absolute requirement for academic prowess, employers look for evidence of practical aptitude in job applicants. A moderate level of staff turnover was experienced by some large employers, noting that the mobility of young people has been a factor in the past. However a range of factors (including the global financial crisis, and property markets) has resulted in a reduction in the mobility of young graduates [R5].

Larger scale employers (mostly in relatively high-tech industries) were familiar with the former NZCE qualification and associated trade skills, but were much less familiar with the NZDE and BEngTech qualifications. Respondent [R4] reported finding the provision of Bachelor’s degrees by Polytechnics “*confusing*”. Our perception is of a vicious circle – where low enrolment in the NZDE and BEngTech degree programmes results in low application rates from graduates for work positions, and low subsequent awareness of the qualification by employers. Employers therefore do not inform schools and career advisors of the desirability of these qualifications, reinforcing low enrolment in the programmes. Large employers spoke of a declining presence in industry of highly skilled people (level 6 and 7 in NZQA equivalence), typically trained in Europe, working in the space between trade and professional engineer.

Respondents [R3] reported a shortage of skilled technicians and technologists in the design area:

“...we have a huge problem finding designers (draughtsmen, CAD/CAM competent industrial designers)-the kind of people who design equipment for manufacturing etc. These are the kind of people who might have level 6 qualification; NZCE or NZDE with specialism in design.”

“It’s really hard to find them...the last guy we got was recruited from France”

“We have gone from a situation of having 10 draughtsmen to every engineer, to having 1 draughtsman to every 10 engineers.”

SMALL TO MEDIUM ENTERPRISES

The situation for small to medium enterprises (SMEs) is different to that in large industries. An industry research organisation [R7] representative reported widespread difficulty for SMEs in securing skilled employees. He spoke of needing people in the design to manufacture interface such as CAD CAM technicians. The profile of desired employees is relatively mature non-degree qualified people with a reasonable knowledge base but with practical aptitude – a close fit for NZDE and possibly BEngTech graduates. A key factor for small businesses taking on new employees is risk: small industries don't have the same ability to take risks as larger ones [R7] and new employees - especially fresh graduates - constitute a significant risk.

Respondent [R5] observed that high-tech manufacturing service industries are vulnerable to fluctuations in economic activity, reporting instability in highly skilled trade/technologist-dependent industries such as tool-making. Industry representatives from high-tech manufacturing and the IT industry reported a growing trend in looking offshore for skilled services. Our observation is that globalisation acts in two ways – providing new markets for local technologically competent industries, but making the outsourcing of technologically demanding tasks (such as the design and machining of close-tolerance tooling) an attractive option.

In summary, large industries prefer to employ top engineering graduates (level 8, including IT), valuing the underpinning knowledge-base of university-qualified graduates. They do not perceive that there is a shortage of the types of graduates they need. They reported that skills can be taught, but the essential knowledge-base and the highly valued ability to continue learning are most predictably present in level 8 graduates. Large employers also value social skills and practical aptitude. Some large employers (and many SMEs) are aware of the shortages in level 6 and 7 engineering employees. Large industries are prepared to teach NZQA level 8 graduates skilled applied tasks, while graduates generally accept and even value this aspect of their work [R17].

Small industries typically value 'rounded' employees with practical aptitude, adequate underpinning knowledge and social skills, but do not expect the high-level competence of level 8 honours graduates. These 'rounded' employees are difficult to find [R3].

IT INDUSTRIES

Our respondents provided a perspective on the characteristics of IT students and the needs of the IT industry. "IT" is used here as a generic term covering disciplines and tertiary programmes such as information technology systems (ITS), information and communication technology (ICT) plus electronics, computer engineering, signal processing and related subjects. Stair-casing in information technology (IT) programmes is directly relevant to engineering in that IT is taught as a discipline within engineering. IT students were reported to differ from students enrolled in pure engineering disciplines. IT student cohorts tended to include a proportion of students described by a university manager/academic [R16] as very "clever" and "number-orientated" but not "socially engaging", contrasting with non-IT engineering cohorts who tended to include larger numbers of "hands-on", "non-academic" students. Lorenz and Heinitz (2014) reported a disproportionately high number of individuals displaying characteristics consistent with Asperger's syndrome or high functioning autism compared to many other industry sectors. While some respondents had encountered such individuals, they also reported a normal proportion of very well-rounded students with good social and communication skills in both IT and non-IT engineering student cohorts. Industry requirements, especially SMEs, were for well-balanced employees:

"What is sought is interpersonal skills and work experience." [R3]

The 'lack of social engagement' observation is supported by reports from the present authors' academic colleagues of significant numbers (of IT students particularly) not engaging socially with other students or even attending lectures, but performing well in summative⁴ assessments. This is identified as a potential problem for institutes of technology or polytechnics (ITPs) and universities because employer representatives value graduates who can operate well

⁴ 'Summative' assessments are assessments designed to assess student capability, competence and knowledge as opposed to formative assessment that is designed as a pedagogical component of learning.

in teams or work groups. IT industries were reported to be increasing their use of inter-disciplinary teams.

A Government department IT manager [R18] stated:

“We are very focussed on teams here ... so the ability for a new appointee to be able to work well within a team environment, have good communication and social skills is very important to us. We would prefer to take someone with less academic skills but is more able to fit within a team than the other way round.”

The three accords to which New Zealand providers of engineering education are signatories (the Washington, Sydney and Dublin Accords) define required levels of competence in a range of areas. In interview [R8] categorised these as:

1. Underpinning knowledge (science and maths)
2. Technical capability (technology)
3. Contextual capability (social learning areas)

Social learning areas specified in the accords include: - individual and team work, communication, management of engineering activities and project management in multidisciplinary environments. These skills are relatively easily addressed in pure engineering education programmes where project-based learning can be adopted as pedagogy; however the development of strategies for building social skills deserves further attention in IT-specific engineering programmes where technical capability can be developed interacting with computers rather than people.

The proportion of students progressing to honours degrees is much smaller in IT engineering programmes than in other engineering disciplines. A respondent [R7] who had, as part of his role, found work placements as internships for IT students reported that they invariably became employees of those organisations (before graduating). An IT academic colleague of the authors commented that the demand for IT employees is so great that students are invariably offered paid positions before they complete their degrees, meaning that only a few continue to honours or post-graduate level studies. Whereas supply and demand for engineering honours graduates (other than IT engineers) is roughly balanced, and demand exceeds supply at levels 6 and 7, the demand for IT graduates exceeds supply at all levels.

Professional and applied engineering

Our research indicates a “blurring” of the traditional distinction between professional and applied engineering. For example, professional engineers are required to have knowledge of rapidly advancing manufacturing technologies such as additive manufacturing. Engineers who have followed an applied path may advance to management positions – this has been the case since the 1960s at least [R14], but new programmes in the UK (Goodyer & Frater, 2015) are offering apprenticeships as pathways to professional careers.

A consistent theme in our interviews was the benefit of context in learning situations. Students who have followed an applied path may have had useful exposure to the social and team environments of industry, and be perceived to be more “employment ready” than students who have followed traditional professional learning programmes. In response to the need for greater contextual awareness and social skills, universities have incorporated project and problem-based learning into their programmes, mimicking real work environments. A recent BEHons graduate [R17] valued the hands-on, contextual components of project-based papers, and expressed the view that if an apprenticeship degree had been available he would have preferred it.

SOCIAL DISTINCTIONS

In contrast to [R17]’s viewpoint, several of our respondents reported student preference for (if not prejudice against) types of work that equated more or less to traditional class structures. Applied learning programmes are associated with blue-collar, trade employment; whilst higher degrees and professional engineering are associated with white collar employment. Cutting across this underlying social distinction are individual intelligences and preferred learning styles which might, in the absence of social distinctions, point individuals to a particular type of learning programme (Silver, Strong, & Perini, 1997). For example, people whose social background might lead them towards an academic programme might learn more effectively in a vocational programme. Respondent [R14] described engineering colleagues who had ‘risen through the ranks’ from vocational programmes through to professional engineering status, and felt that these individuals were generally well-rounded, capable and respected engineers.

The AUT Experience as an Exemplar of Stair-casing Pedagogy

(Geddes & Stonyer, 2003) reported that the New Zealand tertiary sector was improperly configured for the future needs of the “*knowledge economy*”. Heather Stonyer and the late Roy Geddes provided a synopsis of the post-millennial situation that is still relevant over a decade later.

There was (in 2003) an imbalance in students studying business-related courses compared to science and technology where the perceived future needs lay. Geddes and Stonyer reported that the workforce required to drive the future knowledge economy was increasingly being represented through descriptive terms and rhetoric such as “*life-long learners*” and “*highly skilled*”. They reported the success of the Auckland University of Technology (AUT) initiative which has successfully challenged the NZ paradigm of segregation of vocational and academic programmes, creating integrated stair-casing of vocational certificates and diplomas through to academic degrees.

Geddes and Stonyer (2003) refer to AUT’s “*network*” of courses, spanning vocational and academic subjects as a “*stair-case*”. While the term ‘network’ seems slightly at odds with the more simplistic stair-case metaphor of ‘a foot placed on multiple levels’, it is AUT’s successful approach that we have identified as the benchmark for the present investigation. The AUT model appears to have achieved many goals that have proven difficult for the rest of the sector, including features such as:

- Articulation of vocational courses to higher (Masters and PhD) levels
- Flexibility; expressed as multiple entry and exit points
- Facility to design personalised programmes

The authors wrote:

“The ‘staircasing’ model is effective and produces good quality graduates from a pool of students who might not have been admitted to degree programmes at the more ‘traditional’ universities because they lack ‘academic orientation’ (Biggs, 1999). One quality measure of the success of the programme stair-case approach is the graduate rate of employment in relevant industries. At AUT, this currently is running at between 85% and 100% of graduates.”

Geddes and Stonyer attribute the AUT stair-casing structure with the educational status of pedagogy. AUT has achieved learning outcomes through structural design. The success of the course design relies on the small class sizes required to facilitate the transition to tertiary learning for groups who would not be able to learn in the typical large undergraduate classes of other universities.

The authors report another constraint – the focus on research outcomes as a key measure for Government funding. The example they give is the strategic removal of Post Graduate Diplomas (consisting of taught papers without research components) from University programmes. The implication seems to be that the stair-casing pedagogy is effective as a teaching strategy, but that it requires a different funding mechanism than the university research capability based model. A further conclusion is that the present funding strategy serves a narrow “*elite*” group, but is ineffective as a strategy for achieving the stated goal of a broad population of “*life-long learners*”.

The AUT stair-casing programme is designed to meet the needs of people outside the typical university student profile. This includes higher representation of the 25 plus age group rather than the school leaver age bracket. This 25 plus demographic may have a different life-focus (more pragmatic than idealistic) than younger students. Their needs may be better met by qualifications that closely match employer requirements, rather than the more open-ended career opportunities represented by university research programmes.

Geddes and Stonyer drew the inevitable conclusion that achieving the stair-casing model on a broader scale would require focused funding interventions from Government. The logic of their arguments is difficult to avoid:

The predicted requirements of the future “*knowledge economy*” call for significantly greater numbers of science and technology graduates

1. Current educational strategies are resulting in high numbers of business and commerce graduates, but insufficient science and technology (including engineering) graduates.

2. Current science and technology graduates are drawn from a relatively narrow socio-economic sector. There is a wider pool of capable students (many of whom may not include science, technology or engineering careers in their windows of choice).
3. New Zealand industry needs cannot be met by the relatively small number of students who able to learn through the least expensive teaching programmes (i.e. large classes with relatively little interaction between teachers and students). To compete globally it needs to develop strategies to teach essential skills and knowledge to a broader spectrum of the population, and to attract those groups to its learning programmes.

These authors challenged Government research-based funding policy, arguing that efforts to achieve greater numbers of science and technology graduates to service a knowledge economy currently demand subsidisation of those subjects from other sectors. Small engineering classes at AUT are effectively subsidised by students enrolled in the wide range of other subjects that are less expensive to deliver. They further argue that funding academic institutions primarily on the basis of research outputs denies the complex interactions required to prepare students for employment in the knowledge economy. They wrote (p379):

“Learning for the knowledge economy and society needs to recognise both the process of acquisition of knowledge and skill and the learning arising participation in a scientific community (Wenger, 1998) which has both research, community and industry/ employer aspects.”

The AUT model offers an important exemplar for stair-casing as a strategy for addressing engineering graduate shortages. It is unlikely that the unified university/polytechnic model could be as effective outside of a main centre, and possibly outside of Auckland, but co-operative arrangements between polytechnics and universities could achieve similar outcomes. This level of co-operation would require incentivising, as polytechnics and universities are presently in a competitive situation with respect to a limited supply of maths and science school graduates.

Stair-casing mechanisms such as small bridging classes for maths and science are resource intensive and therefore expensive for tertiary institutions to deliver, but not as expensive (to the wider economy) as the opportunity cost represented by a lack of skilled

resources in a technology-driven economy that should be competing globally.

Career choice

A significant area of understanding that has received insufficient attention, particularly at policy level, is the process by which young people make career choices. Becoming an engineer may be thought of as just learning the skills and knowledge to function as an engineer. However becoming anything requires change – and making career choices requires young people to confront change. Young people instinctively appreciate the changes required of them, and make rational decisions constrained by imperfect information and sociological frames of reference.

(Hodkinson & Sparkes, 1997) develop this theme, proposing the term “*careership*” to encapsulate the critical elements of career decision making. They argue that policy-makers implicitly acknowledge pragmatic, rational decision-making based on free choice as the exclusive driver of career decisions. Sociological and geographical factors such as class, local opportunity and gender are often ignored. In contrast the authors report an over-riding sense of determinism in academic literature, implying that career choices are very strongly influenced by sociological factors. A third, arguably under-rated influence they report is “happenstance” or serendipitous decision-making based on opportunity. Critically, they explain that people will only make decisions within horizons constrained by their cultural, sociological and personal identity – their *habitus*. Career decisions cannot be separated from the context of family background, culture and personal life history.

The ‘careership’ model offered by Hodkinson and Sparkes rejects the popular “career trajectory” model as adhering too close to determinism, describing career development as a number of turning points separated by periods of routine. These routine periods may be *confirmatory* (positively building on the turning point decision), *contradictory* (negatively undermining the decision point), *socialising* (conforming the person to a new cultural identity) *dislocating* (forcing people into an identity they reject) or *evolutionary* (a slow, non-traumatic change into a new identity). The turning points involve more radical transformations, where people move from one habitus to another. Turning points may be *structural* (caused by external structures such as completing schooling), *self-initiated* or *forced* (i.e. through redundancy).

This model informs our study of engineering education. Students are effectively forced around year 13 to make career decisions following schooling. For those who have decided (or been guided) toward an engineering career from earlier years, the required change will be less traumatic if the routine period has been confirmatory. A change from school student to tertiary student is certainly socialising, but if that change also involves a commitment to an engineering career several forces come into play. (Billett, 1996) p266 wrote:

“A socio-cultural pathway to expertise is associated with immersion in a particular social situation over time, and acquiring not only skilful knowledge, but also the facility to engage successfully in the discourse, norms and practices of the particular community of practice.”

Students studying in any discipline leading to a defined career-path undergo socialisation into their profession (e.g. doctor, engineer or hydrologist) and concurrent socialisation into “tertiary student”. These two distinct identities may reinforce each other, but depending on the education model, one identity may become dominant. The apprenticeship education model implies a transformation into ‘paid employee’ followed by an evolutionary transformation into ‘engineer’, with the transformation into ‘tertiary student’ playing a lesser role. The university-based professional engineering programme requires transformation into ‘tertiary student’; however the transformation into ‘engineer’ relies on confirmatory and socialising changes through mental models

promoted by teachers or designed into courses (e.g. as project-based learning). Intermittent vocational experiences (e.g. as internships or practicums) are clearly a critical mechanism for achieving this change. The (Hodkinson & Sparkes, 1997) lens reveals that the learning-institute-based model requires a second structural transformation (i.e. relocation into a working environment) at the completion of tertiary training that apprenticeship models do not. The nature of this second transformation is implied in employers’ assessments of students from integrated apprenticeship or co-op models⁵ as being more “work-ready” than graduates from traditional tertiary institution programmes (Mourshed, Farrell, & Bartob, 2012).

The insights of these authors show that the provision of pathways is not the whole picture, as its effectiveness is based on the questionable assumption of rational decision making. If we wish to modify young people’s behaviour through course design, funding and public policy we need to consider also the turning point transformations that are required for individuals, the visibility and clarity of those transformations and the periods of routine change between. A proposal we make is to design career progression options that lower the perceived trauma of significant transformations, and shift them from ‘turning points’ to evolutionary ‘routine periods’. Such strategies would make engineering careers more attractive and more accessible, and would have more successful outcomes than at present.

⁵ ‘Co-op’ is roughly synonymous with ‘sandwich’ models – where students have periods of employment-based learning alternated with periods of full-time study.

Primary school to secondary school transition

To understand the issues relating to primary school level transitioning, we spoke with:

- the principal of a multicultural primary school in Palmerston North [R10],
- a former deputy principal from Hawke's Bay, who had taught from yrs 1-8, had been employed in ministry and privately funded professional support, and is currently working with beginner teachers as a maths coach [R11].
- an academic interviewee who was also the Board of Trustees chairperson of a Waikato School [R16].
- A secondary principal [R9]

Several of our industry interviewees also contributed to our understanding of this issue.

A critical transition in the engineering pathway is from primary to secondary schooling, where only about 20% of primary graduates enrol in STEM subjects (science, technology, engineering and maths) that would enable progression to tertiary engineering programmes. For example, in 2014 national education statistics reported 10,885 of a total of 261,233 students enrolled in maths with calculus (MOE, 2014). A senior university engineering academic [R15] identified maths with calculus as the primary barrier to student progression into higher tertiary engineering study.

Primary maths

There is a widely acknowledged issue with the delivery of maths and science in primary schools, characterised by general dissatisfaction with current maths programmes. We encountered mixed opinions about the efficacy of the Numeracy Development Project (Numeracy Project), an initiative to develop maths capability in schools, introduced between 2000 and 2009. One reported perspective is that the Numeracy Project enjoyed success when it was first implemented, but that success was achieved through a high level of support given to teachers at its introduction – a level of support that has subsequently been withdrawn [R10]. Nevertheless teachers who are confident with the programme are positive about its value and effectiveness when taught well, reporting that the logical progression of understanding achieved through the Numeracy Project provides pupils with a very strong basis for future success in maths [R11]. However, many teachers are still not confident with the programme and

find the physical teacher support material supplied to be inaccessible. Interviewee [R11] stated:

"Teachers find the Numeracy booklets difficult to teach from and follow. When working with a small group, teaching a new maths concept, teachers have said they find the booklets are frustrating and unclear. The number framework is however helpful."

However:

"Students' support material is plentiful, well supported by publishers who have seen a need."

The interviewee explained that primary teachers resort to teaching directly from these commercially provided resources, which although frequently fine in themselves, do not address the fundamental concepts of the Numeracy Project. The Numeracy Project has *"fallen over at the last hurdle"* [R11].

The numeracy project entails concepts that require significant professional development for teachers to assimilate. Despite the initial efforts, teachers do not currently receive the level of upskilling required to understand – let alone teach - these concepts. Inadequate teacher support material is a further 'nail in the coffin'. Current maths (and science) resourcing in terms of ministry-funded support was described [R10] as *"pathetic"*.

A reported perspective [R10] is that the *"pendulum has swung too far"* in the direction of *"number and strategies"*. Some children are held back from progressing because they haven't achieved competence in a specified range of strategies, when competence with basic strategies might be sufficient. This perspective mirrors conclusions of a privately commissioned report (Patterson, 2015), and we cannot discount that the possibility that some of the opinions expressed to us were influenced by that report. Alternatively Patterson may have expressed ideas that are widespread in teaching circles, but haven't previously been published. Some schools are reported to be rejecting the Numeracy Project in favour of alternative programmes [R16].

The issue of teacher capability and aptitude is also critical. People with excellent maths and science have a wide range of career options, so very few people who have excellent maths and science backgrounds enter the primary teaching profession. Teachers who are not confident with maths and science are not likely

to inspire pupils in those subjects. With respect to Numeracy Project competence, teachers who received the initial intensive training (2001 to 2009) are generally competent and confident with it, but not all teachers received that training at the time, and teachers who have come into the system since have not received the same training [R11]. The assumption that schools would have sufficient resources to upskill new teachers is clearly false. However, if the ministry-provided teaching support material were sufficiently 'user friendly', the present high level of dissatisfaction and lack of confidence in teaching maths with Numeracy Project resources might not have resulted.

We note the apparent contradiction of the freedom that 'charter schools' have in their curricula, contrasting with the 'top-down' curriculum control imposed on state-sponsored schools. Another anomaly is that responsibility for building teacher skill in the critical area of maths has been devolved to schools, while freedom (in curriculum areas) to respond to customer needs has been restricted in favour of top-down control. A Primary School respondent [R11] commented on the burden of measuring and reporting for National Standards, with a resulting focus on lifting the achievement of a small number of poorly achieving pupils. The focus on achieving National Standards was regarded as a negative influence on maths and science achievement by two other respondents [R8, R9]. Although this focus benefits weak students, it is perceived as unfair to the majority of pupils for whom the standards are less beneficial. The National Standards can therefore be seen to negatively impact the group of students who are potentially the level six and seven engineers of the future. Areas of tension within the administrative devolution of the 1990s 'Tomorrow's Schools' reconstruction of primary education have been examined previously (Townsend, 2002), but the diversion of teacher effort due to the introduction of National Standards requires further examination.

Science

Our respondents identified maths (with calculus) as a critical issue, however the science most closely aligned with maths (i.e. physics) also limits progression in engineering study. It was reported [R16] that many primary teachers lack passion for science, although some excellent science resources are available. A comment from more than one source was that some science taught by primary teachers

is incorrect and has to be "untaught" at a later stage. The discontinuation of specialist maths and science advisor roles is regarded as another negative factor [R9]; significant, but not the primary cause of the problem as the value these advisors brought to schools was inconsistent [R11].

Feedback

Primary schools do not receive precise feedback on the progression of their pupils beyond their boundaries. The lack of a learning feedback cycle (a basic principle of education practice) at the institution level is a somewhat damning indictment of the structural management of the education system. If a mechanism for this feedback cycle was present, schools would at least get feedback on the needs and expectations of the institutions receiving their graduates. From a supply chain perspective, providing feedback at local or regional levels would be far more effective than the current system of providing data at the national level. The recent voluntary 'community of learning' initiative (MOE, 2015) addresses the feedback issue in an informal sense, but it is intended to share knowledge and expertise, falling short of a structured feedback system with sufficient devolution of authority to allow system actors to respond to that feedback.

Chapter conclusions

What is clear is that the current primary school maths curriculum delivered with the current level of teacher support is failing to achieve the success rates required to meet the needs of the economy. A criticism we have of the current system is that while some teachers have received sufficient training to effectively deliver the Numeracy Project, responsibility for training and sustaining this programme appears to have been devolved to schools. The first level of proficiency (practicing) is traditionally associated with Bachelors level qualifications; the second level of proficiency (teaching practitioners) is traditionally associated with Masters level qualifications. A strategic error appears to have been made in assuming that practitioners are also capable of teaching new practitioners.

A review of the effectiveness and success of current primary maths teaching should be undertaken, including the following immediate steps:

- Introduction of a new cycle of professional development of teachers in maths.
- Development of new teacher support material; designed on the basis of supporting teachers' understanding of the Numeracy Project concepts, rather than designed with the assumption of teacher expertise.

The critical result of any intervention is to achieve an immediate, radical increase in student ability at year nine, irrespective of pedagogical ideology. Whether or not a rebalancing of relational versus instrumental maths strategies is required in the long term, and whether the Numeracy Project can or should be taught in tandem with algorithm-based approaches is a question that requires high level consideration.

Knowledge and enthusiasm for science subjects is a different consideration. Not many primary teachers are highly proficient in physics, so the most cost-effective way to improve the awareness and acceptability of students to high school physics might be through excellent resources for teacher professional development and teacher support.



School and Polytechnic to University stair-casing

The move to project-based programmes

In addition to the problem of insufficient underpinning maths (and physics), some universities (e.g. Massey) have moved to project-based engineering programmes combining practical and team-based skills with the acquisition of underpinning knowledge in an integrated four-year programme. This change reflects the notion that engineers have three separate strands to competence building (sect. 3.1.2); underpinning knowledge, technical skills and contextual/social skills.

Project-based programmes achieve the teaching of these strands, reflecting modern pedagogical thinking (Mills & Treagust, 2003). However, Massey University's project-based engineering programme (for example) does not lend itself to stair-casing from other institution's programmes, as the various competence components are integrated throughout the four year duration. Programmes such as these make it difficult to accept students 'mid-way' through standard engineering honours programmes, but they don't prevent institutions from articulating pathways (from BEngTech) to other post graduate degrees.

Polytechnic stair-casing

Students stair-casing to diploma and degree level via level three and four polytechnic papers can be characterised as students who have not achieved sufficient grades at school to be able to enter tertiary IT or engineering programmes [R13]. The typical reasons for failure to achieve these grades and the subsequent decision to enrol in an engineering or IT programme are:

- The student was not interested in IT/engineering at school, and either didn't study STEM⁶ subjects or other prerequisites (such as English literacy), or failed to achieve credits in the subjects they did study.
- The student has (since leaving school) experienced IT/engineering in employment, and/or perceives IT/engineering qualifications to offer employment opportunities

- The student has been encouraged to upskill in IT/engineering by an employer
- The student performed poorly at school, and perceives IT/engineering as accessible subjects for continuing education.

A recent study (AkoAotearoa, 2014) of students enrolled in engineering programmes (mostly level 6 and 7) revealed a group of people who had returned to engineering study after an average of 10 years in the work-force. For this group of people the bridging courses were a critical aspect for success.

Polytechnics offer level three and four bridging courses that enable students to progress to higher levels [R13]. This type of stair-casing is essentially remedial in the sense that it is recovering people who have departed from the main school-to-tertiary education pathway. Remedial stair-casing is certainly important, as many young people do not comprehend the skills they will require to meet the needs of employers, and as a result do not study subjects that will allow them to enrol in programmes to gain those skills. Employer needs are more visible after people have joined the workforce. Even so, the fact that students leave the education system without gaining qualifications they subsequently prove they were capable of gaining suggests weaknesses in the education system. A specific weakness is failure to identify student learning styles and intelligences (Campbell, Campbell, & Dickinson, 1996; Coffield et al., 2004) or personality types and aptitudes which if known would allow schools to better direct students toward suitable career paths and suitable mechanisms for accessing those career paths (Dunning, 2001; Felder, Felder, & Dietz, 2002; Myers & Myers, 2010).

Examination of two of the reasons above (with specific attention to engineering) reveals some factors that require further attention:

- a. The student was not interested in engineering at school

Creating interest in subjects at school is arguably the responsibility of the school. Engineering needs to be actively promoted as a suite of desirable career paths. Our interviewees consistently reported a wide range of roles and expectations for employees who are designated 'engineers'. It may well be that the

6 STEM – science, technology, engineering and maths

term 'engineer' has lost some of its usefulness, and that awareness (through a broad range of marketing strategies) of a selection of clearly defined subgroups of engineering would be more appropriate.

- b. The student didn't study engineering subjects, or prerequisites for entering further engineering study, or didn't achieve the required grades in the subjects they did study.

Engineering subjects are not taught at primary school, and many students don't have any engineering role models in their family. For students who have been encouraged to study and succeed in maths and science subjects at secondary school, engineering is a viable option when they become aware of engineering as a career choice. However, low uptake of maths with calculus (and physics) at secondary school has resulted in a barrier for many students.

Bridging courses have proven to be an effective stair-casing mechanism to enable students to enter the engineering profession at an appropriate level to meet the needs of the future economy (IPENZ, 2010). This type of 'remedial' stair-casing is essentially a re-active solution to a situation that ideally wouldn't exist. If sufficient numbers of students exited schooling with the desired prerequisites, and sufficient numbers of these progressed to level 5-7 qualifications, the need and opportunity for bridging courses would be reduced. However, the AkoAotearoa (2014) study demonstrates that a pool of potential engineers exists in the community and that stair-casing strategies can effectively capitalise on this pool.

An important proviso to this conclusion is that the stair-casing option is neither efficient nor inexpensive. A study of the experience at one New Zealand University (Geddes & Stonyer, 2003) shows that small bridging classes, while effective, are resource-intensive compared to typical large undergraduate university classes. However the cost of stair-casing should be balanced against the loss of productivity from having potential engineers pursue unrewarding career paths (most typically unskilled employment) for, on average, the first decade of their lives (AkoAotearoa, 2014).

University Stair-casing

Universities offer their own stair-casing mechanisms, generally in the form of foundation maths and physics papers that they may require a student to complete before gaining entry to a degree programme. Such

papers are intended to cover a range of situations, from people returning to study after a period in industry to foreign nationals whose prior learning needs to be assured before enrolment in New Zealand degree programmes. Students who have completed polytechnic qualifications may be required to complete these stair-casing programmes as a pre-requisite for further study. We haven't identified any specific issues in the design or availability of these stair-casing mechanisms.

A level of tension was revealed in conversations with polytechnic and university representatives [R12; R15; R6]: Polytechnics expressed the view that when applying for higher degrees their graduates were treated harshly in terms of the recognition of their prior learning, while university and industry commentators expressed the view that the underpinning science and maths taught in polytechnics was not as demanding as that taught in universities.

Chapter conclusions

While we have concluded that efforts should focus on reducing the underlying cause (primary school mathematics) of the identified system constraint (calculus and physics proficiency), further funding and incentives targeted toward motivated students with the goal of stair-casing into NZDE and BEngTech would have benefits for the economy and society at large. Respondent [R13] reported that students with work experience are typically more motivated than school leavers.

The transition from school or employment to Polytechnic is a transition where stair-casing has proven to be effective. The low uptake of STEM subjects at year nine results in a pool of people leaving school at year 13 (or earlier) or in employment who have unfulfilled potential as level 6 or 7 engineers, but do not have the necessary underpinning knowledge. People who have been in employment typically have the contextual and social learning areas employers value, while school leavers lack this essential social competence. Stair-casing through bridging courses is an especially effective mechanism for people who have been in employment and are motivated to upskill. It is however expensive to deliver due to small class sizes, and requires significant personal sacrifice for individuals who typically have families to support. Small businesses may not have the resources to support people taking time out of work to upskill, even if they need the skills 'on offer'.

The supply chain perspective - engineers as a resource for industry

Supply chain theory has previously been applied to education (Habib & Jungthirapanich, 2008). Supply chain concepts such as end-user, feedback and system constraints are readily applicable to the supply of engineers to industry.

A consistent picture was presented to us of a supply chain in which many actors are only vaguely aware that they were part of a supply chain. Primary schools do not consistently receive feedback on subject enrolments of their students at secondary school, or on their success in tertiary study. The feedback that does occur is informal, and is not used to modify or improve teaching practice. Secondary schools appear to be more aware of the professional careers and degrees and trade careers than the middle ground of technician and technologist. There is evidence of informal communication between adjacent elements of the supply chain (secondary and primary principals; Polytechnics and schools; Polytechnics, Universities and industry), but never 'all in the same room at the same time'.

Our criticism of this system is that while information is passed to the meta-system (the Ministry of Education), top-down reaction to data is not an adequate strategy in isolation for continuous system improvement. Successful systems such as that in Austria (Archan & Mayr, 2006) exhibit structural elements that enable communication between all elements of the system.

System constraints

The theory of constraints [TOC] (Cox & Schleier, 2010) is a useful model for analysing supply chains and proposing strategies to address system constraint. A key tenet of TOC is to identify bottlenecks or constraints and to exploit those constraints as a means of improving the system.

A senior engineering academic [R15] identified ability in mathematics (specifically calculus) as a constraint for the professional engineering pipeline. Corollaries of this constraint are:

- BEngTech graduates are typically insufficiently capable in mathematics for the BEHons programme

- A danger exists that in attempting to build stair-casing opportunities from BEngTech to BEHons or Masters level engineering degrees, notwithstanding offerings of appropriate bridging courses, students who are relatively weak in critical areas such as calculus and physics are admitted to programmes. [R15] referred to this danger as "*the tail wagging the dog*", concluding that a "*three plus one*" (3 ITP + 1 University honours programme) was not a sound proposition.

We note that this situation is an issue for the present, and that in a future state where students with excellent maths and physics are encouraged to enter 'apprenticeship degree' programmes, the constraint would not exist to the same extent.

STRATEGIES FOR EXPLOITING THE CALCULUS CONSTRAINT

Having identified the system constraint, the next stage in the Theory of Constraints (TOC) process is to 'exploit' the constraint. Strategies to achieve this include:

- Identifying those engineering careers that require alternative skills and aptitudes (e.g. statistical maths, soft skills, people and project management).
- Designing stair-casing pathways for professional courses that don't require calculus proficiency.
- Identifying students with calculus aptitude early (year eight) and targeting them for engineering careers.
- Introducing incentives (to students, teachers and schools) to progress with STEM subjects from year 9 to 13.
- Exploring mechanisms to attract poorly represented groups into engineering.
- Developing early teaching aids (such as computer games) that develop mental pre-conditions for learning calculus.

The TOC response would include creating a buffer before the constraint. An effective strategy would therefore require a surplus of calculus and physics capable students exiting secondary school, rather than supply balanced to industry requirements (customer demand).

Stair-casing, the calculus constraint and sponsored degrees

We consider here the ramifications of policy decisions (i.e. funding mechanisms) proposed in earlier research (Goodyer & Frater, 2015); policy decisions enabling degree apprenticeships or 'sponsored degrees'. If greater numbers of calculus proficient students were to choose vocational (ITP or employer-based) programmes this could compete directly with the undergraduate intake pipeline for university-based professional engineering degrees. This would in turn justify articulation to level 8 professional engineering programmes, and perhaps a single 'add on' university year to complete a professional degree, notwithstanding the present incompatibility with project-based programmes.

Industry consultants [R3] noted that what is needed is not only an increased stream of level 6 and 7 engineering graduates, but a pool who are content to develop their careers in that technical/technological environment rather than seeking progression to professional engineer status:

"We really need people who want to be designers and stay designers. Graduate engineers want to be engineers and do interesting things."

Given that the projected numbers of professional engineering graduates already meet projected demands, and that employers are looking for technician/technologist employees who are content to remain at that level, the justification for developing articulated or stair-cased pathways beyond the BEngTech⁷ is to increase the attractiveness of vocational pathways to all stakeholders; specifically students, parents and career advisors. The expectation is that progression to higher degrees would become more competitive, and that a larger pool of skilled people with a wider range of capability would be available at level six and seven.

If 'sponsored degrees' or 'degree apprenticeships' were developed as a desirable option, some highly capable students would choose this pathway. These students would be capable of progressing to professional engineer status, and it would be up

to universities and polytechnics to articulate their progression. One commentator [R8] spoke of the "multiplier effect", seen where small numbers of students receiving scholarships draw in a larger group of fee-paying students. The attraction of highly capable students to a vocational stream would potentially have this multiplier effect, resulting in a larger pool of capable people in the critical industry technologist space.

THE ENGINEERING MANAGEMENT DEGREE OPTION

A senior manager in our interview group [R4] noted that the normal pathway for advancement for a level 6 or 7 employee is management (rather than professional engineering). A logical development for universities would be to articulate pathways from the BEngTech, or the sponsored degrees proposed by (Goodyer & Frater, 2015) to level 8 engineering management degrees. The management pathway would typically require statistics capability, but not necessarily calculus.

Conclusions from supply chain considerations

Viewing the engineering education system as a supply chain provides a richer picture than the simple stair-case metaphor. To operate as an effective supply chain the actors in the system should communicate freely, provide structured feedback to upstream system actors and should have freedom to respond to each other's requirements. Poor outcomes in the teaching of primary school maths (and to a lesser extent science) are identified as underlying causes of the system constraint (calculus competence at year 13). Focussing on the constraint and, in the terms of the theory of constraints, *elevating* the constraint should be the key focus of any intervention.

In Chapter 8 we describe a structural intervention based on regional co-operation.

⁷ A level 7 engineering degree offered by some polytechnics

Conclusions

The need

There is clear and present demand for level 6 and level 7 engineers to complement the existing (adequate) supply of level 8 graduates. Organisations report having to look overseas to fulfil their need for suitably qualified technicians and draughtsmen (sect. 3.2.1). NZ is not producing enough to meet the identified needs of employers. The following conclusions are aimed at addressing this problem.

STRATEGIES TO ATTRACT GRADUATING SCHOOL PUPILS TO CAREERS IN ENGINEERING:

The concept of an engineering career must be deliberately introduced into the decision horizons of greater numbers of young people. Our research shows that young people are not motivated to study challenging subjects to achieve qualifications for careers of which they have limited awareness. Initiatives could include exposing young people to role models (e.g. through marketing strategies such as sponsored character creation in popular TV programmes).

Training pathways should not imply or require traumatic change, while career paths should have 'escape routes' – potential future transformations into alternative pathways. A criticism made [R12] based on experience in a European system was that students who were identified for an engineering pathway from age 14, found it difficult to leave the pathway. That system claimed to offer permeability (the ability to move horizontally during training from one career path to another). In the event social pressures made escape from a predetermined career path difficult.

STRATEGIES TO ENHANCE THE SUCCESS OF EXISTING PROGRAMMES:

Programmes should facilitate evolutionary change into 'engineer' using mechanisms such as social interaction with graduate engineers, recognising the concurrent and potentially contradictory transformations into 'tertiary student' and 'engineer'. Strategies should be developed for these two transformations to be self-reinforcing.

The tendency for IT students to be "number orientated" and not "socially engaging" directly conflicts with employer needs for socially competent people and multi-functional team skills. This area should be addressed at all levels, from secondary school through to polytechnic and university programmes.

CONCLUSION FROM "THE MANAGEMENT DEGREE OPTION"

Universities in consultation with polytechnics should identify, develop and articulate progression from the BEngTech to appropriate higher engineering management degrees. The option of a higher degree as an endpoint to vocational training will make the vocational route (i.e. sponsored degree) acceptable to more capable students. However the BEHons is not currently a natural endpoint for NZDE and BEngTech graduates. In a future state with calculus and physics competent students following an apprenticeship degree (or sponsored degree) pathway there would be benefit in focussing on articulating this pathway to a wider range of professional engineering degrees.

Recommendations

Regional education groupings - an integrated solution

RECOMMENDATION 1

The solution we propose for addressing the critical issue of lack of feedback and communication and control within the engineering education supply chain is regional education/industry groupings (a “hub” or “co-operative”). The purpose of these is:

- To get representatives of the actors in a region into the same room on a regular basis, including primary and secondary principals, university plus polytechnics, and small to large industry representatives
- To provide an effective feedback mechanism between supply chain actors on an workable scale
- To provide these regional groupings with a clear data-based overview of the effectiveness of their regional supply chain
- To provide resources, and allow the regional groupings freedom to deliver their own solutions to recognised needs

REGIONAL GROUPING STRUCTURE

The groupings are proposed (initially at least) as a STEM (science, technology, engineering and maths) initiative. Addressing the critical supply chain deficiency in the existing system in communication, feedback and control mechanisms is of urgent importance.

Steps:

1. Create and fund regional bodies, and provide a legislative basis for devolved authority to design and deliver effective regional engineering/science education supply chains to meet regional industry requirements.
2. Identify the roles and appoint (regional) representatives for each of the actors within this body (primary school, secondary school, polytechnics, university, SMEs and large industry).
3. Establish communication systems (within each region, and at the meta-level between regions and to Government).

Primary School Maths

The delivery of primary school maths, and to a lesser extent science, is an underlying cause of the recognised system constraint. An urgent review of the situation is indicated. We recommend that:

RECOMMENDATION 2

A new cycle of professional development for teachers in maths should be introduced. New teacher support material should be developed; designed on the basis of supporting teachers’ understanding of the Numeracy Project concepts, rather than designed with the assumption of teacher expertise.

RECOMMENDATION 3

If the Numeracy Project is to be maintained, responsibility for developing and maintaining teacher competence cannot be with schools (as it is by default at present). We recommend reversing the devolution of responsibility for teacher training from schools back to Ministry of Education.

Other strategies for increasing the numbers of level six and seven graduates:

STRATEGIES TARGETING LEARNING STYLES:

RECOMMENDATION 4

Utilise current thinking around student learning styles and intelligences to identify students with aptitude for engineering before year 9. Develop programmes that exploit learning style theory to prepare and motivate students to continue studying subjects that will enable students to progress to tertiary engineering study.

STRATEGIES TO INCREASE THE ATTRACTIVENESS OF A BROAD RANGE OF ENGINEERING CAREERS:

RECOMMENDATION 5

Identify a set engineering career paths (and marketable names for them) to raise awareness of the nature of engineering as an employment option for young people.

RECOMMENDATION 6

Offer vocational pathways (i.e. work integrated learning models such as industry sponsored degrees) as the preferred pathway to level six and seven engineering qualifications, and a viable pathway to higher degrees (this recommendation follows those made by Goodyer and Frater (2015)).

RECOMMENDATION 7

Design and articulate a NZDE/BEngTech to Master of Engineering Management pathway as a normal path for capable students with moderate maths and science capability.

Stair-casing to NZDE and BEngTech

People who have been in work for a number of years and are motivated to upskill should be enabled to achieve this. We recommend:

RECOMMENDATION 8

Scholarships should be made available for individuals in employment who wish to upskill to NZDE or BEngTech. Those scholarships should be linked to an employer subsidy or tax benefit, encouraging SMEs to support employee upskilling.

IT-specific recommendations

RECOMMENDATION 9

The social competence of IT students should be recognised as an essential component of IT programmes. This can be addressed either through project-based programmes or through vocational, employer-led programmes.

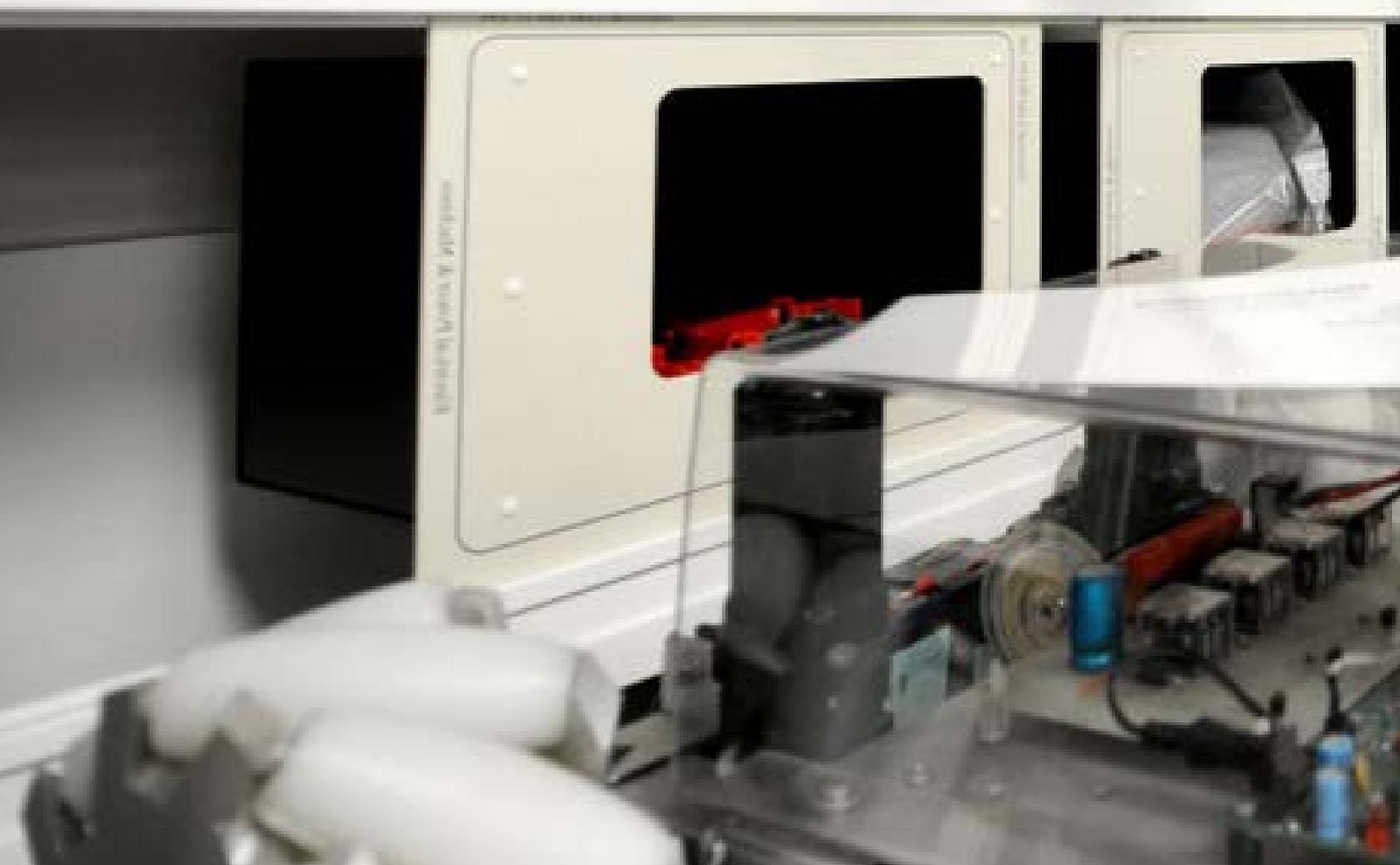
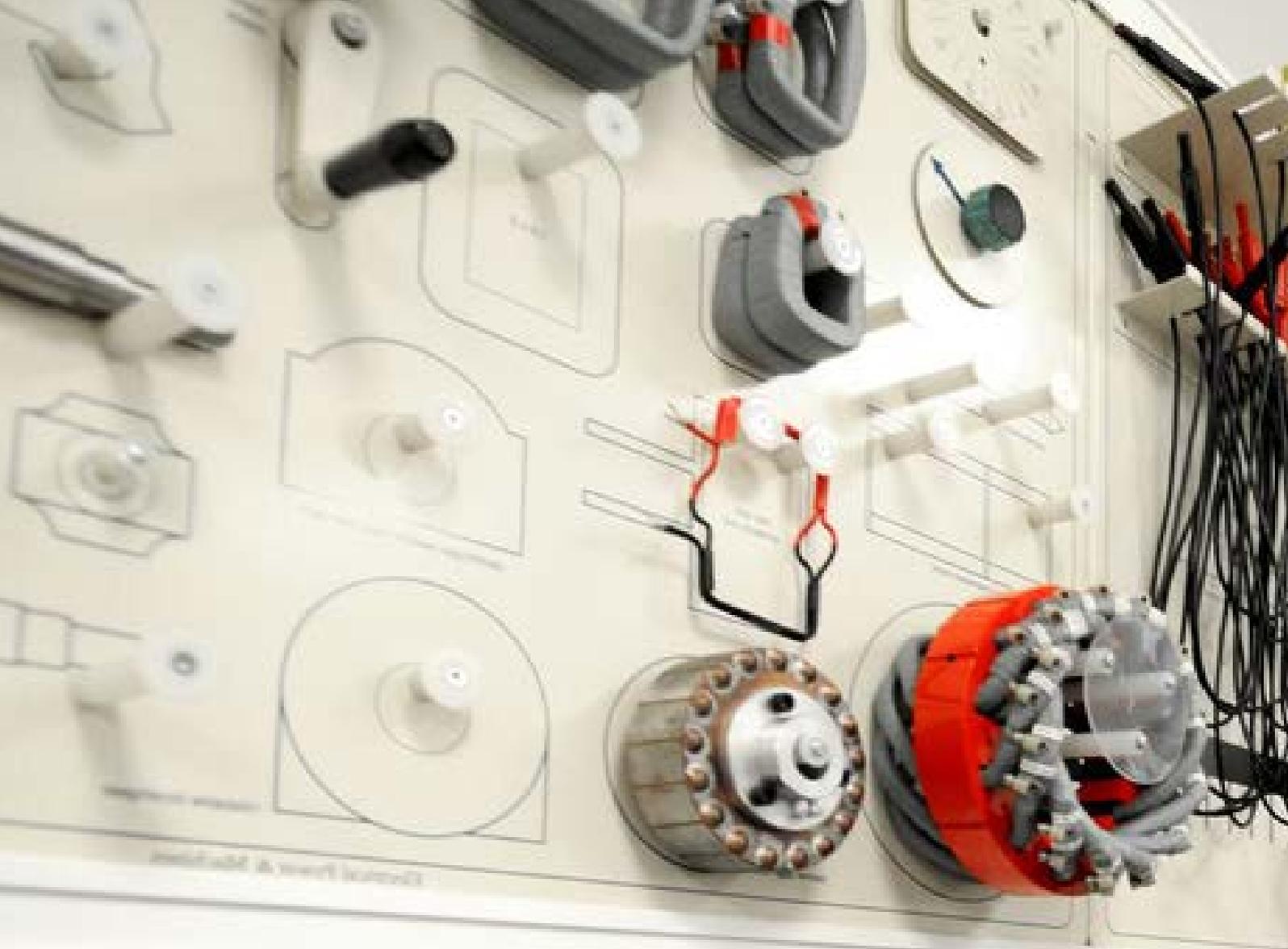


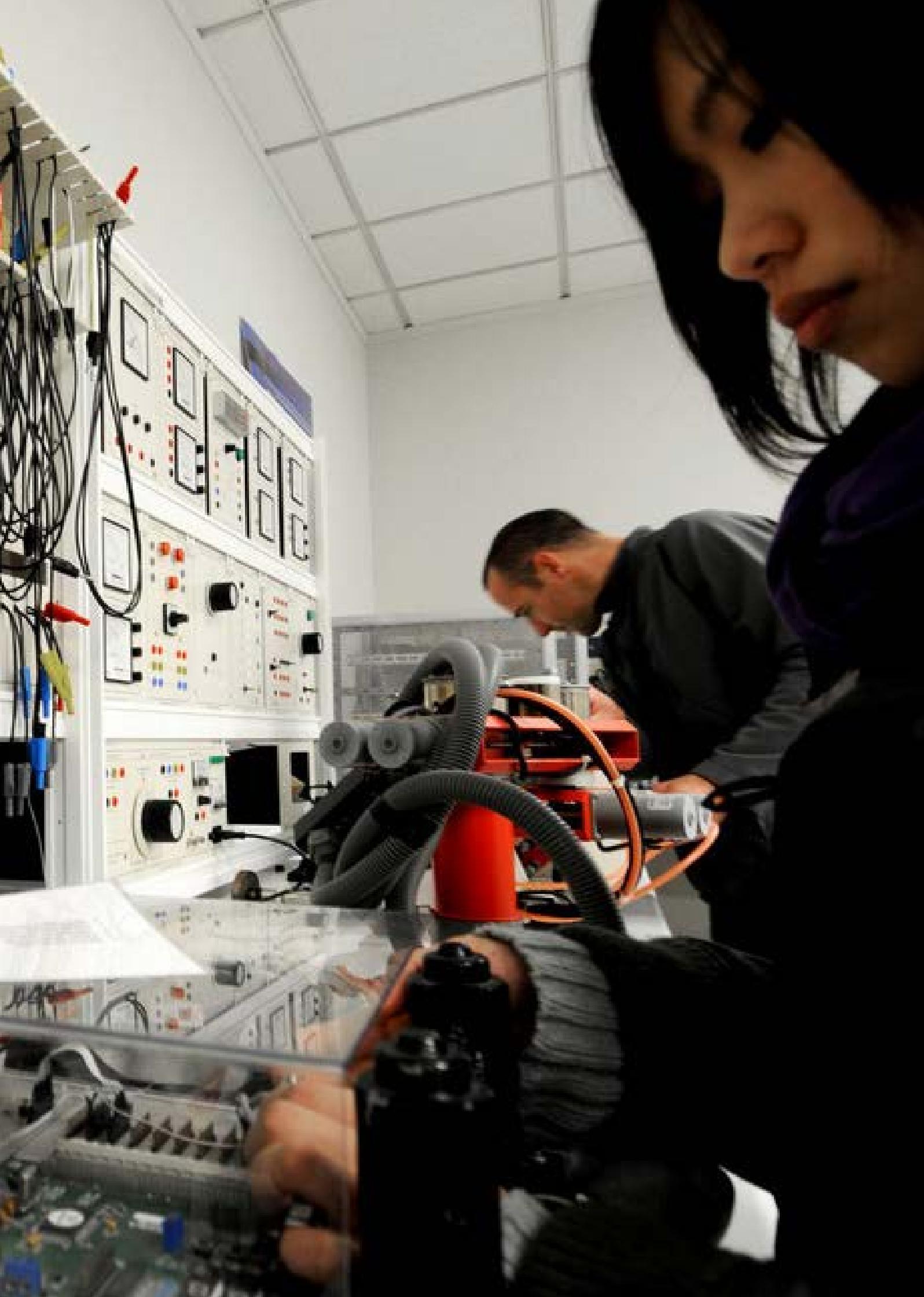
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APPENDIX A

RESPONDENT(S)	SECTOR	ROLE	PERSONS	DATES 2015
1	Primary production	Research and development	2	Oct 12
2	Primary production	Management	1	Oct 22
3	Engineering	Management and consultancy	2	Oct 14
4	Engineering	Consultancy	1	Oct 14
5	Engineering	Management	1	Oct 23
6	IT	Management	3	Oct 15
7	CRI	Management	1	Oct 22
8	Research	Management	1	Oct 1
9	Education	Secondary management	1	Oct 19
10	Education	Primary management	1	Oct 28
11	Education	Primary management	1	Oct 28
12	Polytechnic	Management	7	Oct 1
13	Polytechnic	Academic	1	Oct 21
14	Polytechnic	Auditing	1	Nov 2
15	University	Academic/Management	1	Sept 11
16	University	Academic/Management + Primary BOT	1	Oct 27
17	Recent graduate	Engineering	1	Oct 8
18	Govt. Department	IT Manager	1	Nov 6







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