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STEPPING INTO ONE ANOTHER'S WORLD

APPRENTICESHIPS – TRANSFORMING ENGINEERING TECHNOLOGIST EDUCATION IN NEW ZEALAND

ASSOCIATE PROFESSOR JANE GOODYER AND DR GREG FRATER
SCHOOL OF ENGINEERING AND ADVANCED TECHNOLOGY

e2e ENGINEERING EDUCATION TO EMPLOYMENT

Tertiary Education Commission
Te Amorangi Mātauranga Matua

THE ENGINE OF THE NEW NEW ZEALAND

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APPRENTICESHIPS – TRANSFORMING
ENGINEERING TECHNOLOGIST EDUCATION IN NEW ZEALAND

JANE GOODYER AND GREG FRATER

JUNE 2015

A report for the Tertiary Education Commission

To be informed of future outputs from this research please contact:
Jane Goodyer
School of Engineering and Advanced Technology
Massey University
Private Bag 11-222
Palmerston North 4441
New Zealand
J.Goodyer@massey.ac.nz

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CONTENTS

SUMMARY

The authors have been contracted to advise the Tertiary Education Commission on the viability of apprenticeship models to educate degree level engineering technologists. We have conducted a literature review of learning models that have high levels of employer involvement, supplemented by interviews with tertiary providers involved in delivering new degree apprenticeships.

We have found that there has been a resurgence of apprenticeships as a model for delivering higher education. The challenges of the future require engineering graduates to be more rounded individuals than those educated through traditional means. Apprenticeships deliver this more rounded engineer.

Two key findings are the need for effective collaboration between employers and educationalists at the design and planning stage, and clear pathways to higher levels of education. Employers have to be in the driving seat, specifying degree standards that are outcome-based and occupation-driven.

We have endorsed apprenticeships as a viable learning model for educating engineering technologists and have provided recommendations for establishing new degrees based on an apprenticeship learning model.

Chapter 1 Drivers of engineering technologist education development in New Zealand

In 2010, an extensive consortium[1] developed a national plan, called the National Engineering Education Plan (NEEP), aimed to provide New Zealand with a sufficient number of engineers at all levels of the profession[2]. It was estimated that an extra 2750 graduates per year were needed to support an "innovation led economy" and most growth would be needed to educate engineers at the level 6 and 7 of the New Zealand Qualifications Framework (NZQF), i.e. engineering technicians and technologists. There are many issues that need to be overcome to increase the number of engineers; however on the plus side there are many on-going and complementary initiatives all working towards the same goal of increasing the number of engineering technicians and technologists. This chapter outlines the key issues currently faced in NZ and the initiatives which address them, and explains how this study will contribute to the debate.

National Engineering Education Plan – A Partial Success

A key outcome from this national plan (IPENZ, 2010), put forward to the Tertiary Education Organisations (TEOs) providing Level 6 and 7 qualifications, was to provide substantial equivalence between the Bachelor of Engineering Technology (BEngTech) degrees currently offered and a unified diploma system across disciplines; this potentially allows students more flexibility in their study pathways and location. Another complementary outcome from this plan was to provide a "model" for the secondary/tertiary interface so that there are clear pathways of entry and progression for all students (including adult learners) wishing to embark on an engineering career, that encompasses vocational to professional level complexity. In addition the plan recommended that Schools and TEOs support increasing the engagement of Women, Māori and Pasifika in engineering as a profession.

To summarise, the NEEP project has been extremely influential in how New Zealand's (NZ) educational providers have begun to address educating engineers through: 1) a greater collaborative approach; 2) having a clearer structure around the differences between professions of technician, technologist and professional engineer; 3) how a student can choose the best pathway for their individual needs.

In response to the NEEP project the NZ government, in the 2012 Budget, pledged an additional $42 million over four years to maintain the quality of engineering education in the Tertiary sector and increase the number of engineering graduates (at qualifications levels 5 and above) with a target of an additional 500 graduates per year from 2017 (TEC, 2013). In the 2013 Budget, an additional $9.3 million over 4 years was allocated. Four years on from the initial NEEP report and nearly 2 years of additional funding, the TEC commissioned a report (TEC, 2013) to review the initiatives that tertiary education providers have implemented and identified several concerns and issues these providers face with the targeted increase of graduates desired by the government.

With regards to recruiting new students, there are considerable barriers with the secondary/tertiary interface. First, there are the school leavers who do not have the appropriate subject knowledge for entry to engineering tertiary education. Secondly, there are the new recruits who have difficulty progressing beyond their first year of tertiary study. To add to the situation, there is a lack of public knowledge of engineering and what different TEOs offer. It is concerning that several level 6 and 7 providers, i.e. typically Institutes of Technology and Polytechnics (ITPs), are struggling to attract NZ students to the BEngTech and diploma qualifications, especially as the NEEP project identified that the main growth of graduates should be at these levels. In fact, this TEC report states:

[1] Representing tertiary providers offering engineering qualifications at levels 6, 7 and 8 of the New Zealand Qualifications Framework (NZQF), industry training organisations, the engineering professional body and industry.

[2] level 6 - the engineering technician, level 7 - the engineering technologist and level 8 - the professional engineer

"ITPs complain that students are not informed by their schools that degrees can be done at ITPs. They are also concerned that the value of Diploma level qualifications is not well appreciated, nor do teachers and careers advisors appear to know…. how one qualification can staircase into another, all the way from trades level engineering through to postgraduate qualifications."

This complaint was still being echoed over a year later when the NEEP Reference Group met in November 2014 to identify whether the 2010 NEEP report was still valid. One of the authors (Goodyer) attended the meeting and accessed the private minutes where several issues were voiced. A key issue was that there had been a strong bias towards encouraging students to enter engineering tertiary level at level 8 (i.e. university). One of the reasons for this bias is the group believed that the pathways to university are more understood by influencers such as parents, career advisors and teachers than the students whereas other options, such as through ITPs, are not. In addition, it was highlighted that employers do not understand fully the differences between an engineering student educated at either an ITP or a university. Industry representatives at this meeting also suggested that their industry peers need to provide more learning opportunities for the level 6 and 7 engineers and a mechanism to do this would be to shift away from state funding of TEOs to a more "loose" funding model to encourage employers to participate.

In conclusion it is apparent that some circles of tertiary education, particularly ITPs, are struggling to attract students to study engineering at their institutions. In response the government has provided more funding but this has compounded the problem by allowing further growth at universities, prompting Government to focus efforts on specifically targeting initiatives that can help grow engineering enrolments at level 6 and 7.

Growing the engineering pipeline

In addition to providing additional funding to the TEOs, the NZ government launched the Engineering Education-to-Employment (E2E) Programme in 2014. The E2E Programme is working mainly to address the shortfall of levels 6 and 7 graduates and focuses on four key elements (TEC, 2014):

1. A nationwide marketing campaign to promote a more accurate and exciting view of careers for engineering technicians and technologists
2. Greater support for students who are interested in engineering - through scholarships, bridging courses and other initiatives
3. Creating incentives for greater collaboration between ITPs and New Zealand industry to grow the engineering pipeline together
4. A national plan to increase connectedness between the tertiary and secondary education sector

This has launched many interlinked initiatives such as the Techlink Pathways project (Techlink, 2014), the 'engineering barriers and responses' study (ResearchFirst, 2014) and the Ako Aotearoa 'improving pathways to engineering education' project (AkoAotearoa, 2014).

The Techlink Pathways project is a collaborative project between IPENZ and the Metropolitan Group of ITPs that aims to achieve a significant growth in level 6 and 7 graduates by: 1) increasing awareness of the various pathways to engineering and related career options; 2) helping align school course selection with tertiary entry requirements; 3) improving successful course completions and transitions into productive engineering-related employment.

The Research First study addresses how marketing messages and product delivery can be developed to address the barriers to study the BEngTech qualification at ITPs. It highlighted that the technologist role "the middle ground" is not understood by parents, students and, worryingly, employers, whereas the technician and degree-qualified engineer roles are understood to a greater degree. Also, larger employers use BEHons graduates in technologists' roles, which reinforces the 'murkiness' of this middle ground. What is also worrying is the dichotomy between ITPs providing technician routes through the NZDE and universities providing the professional engineering route through the BEHons. There is a gap of knowledge about how the BEngTech serves the profession. Another issue is that ITPs are considered providers of pathways for 'less academic' students, and that these pathways are seen as easier but of lower quality. The study offers many suggestions to make the technologist career more attractive. The more pertinent suggestions are to use industry to show students the work they could do and to propose that a Graduate Diploma in Engineering Technology could better fit with both industry and students.

The recent Ako Aotearoa Project explored ways to improve pathways to engineering study. It echoes previous studies concerning building awareness of engineering through a nation-wide marketing campaign. However, there were new suggestions of: a common set of flexible engineering bridging courses to enable greater student intake; and greater collaboration, through formal agreements, between tertiary providers to promote smooth transitions and pathways to higher level qualifications. Another suggestion is for the BEngTech providers to consider an industry leadership model (similar to the New Zealand Board for Engineering Diplomas (NZBED) unified oversight of the level 6 NZDE). This could take the form of engineering firms becoming partners with providers in the development of skills (particularly through cadetships); essentially making employers part of the solution.

Structure of the report

These initiatives represent the collective importance of secondary and tertiary providers, employers and the public in this challenge and the three distinct strands that have been addressed in the work done so far. These are: public awareness, pathways into and across secondary/tertiary institutions and employer engagement.

In 2015, Massey University was commissioned by the Tertiary Education Commission to contribute to the third strand of employer engagement. Our role entailed the review of models of employer engagement in education, specifically apprenticeships, to ascertain whether they might be appropriately applied in educating engineering technologists in New Zealand.

This report aims to provide a synopsis of recent literature on the nature of employer engagement at **higher levels of education provision** (i.e. NZQA level 5 and above). It will focus **on employer-led** education models that involve employers actively engaging with tertiary providers to design and/or deliver, and perhaps fund a programme of learning. Whilst the review focuses on apprenticeships, other models such as co-ops, internships and practicums are mentioned but fall largely outside the scope of this report.

The report is structured around four main areas: 1) educating engineering technologists 2) experience-led learning models 3) apprenticeship models and 4) specific case studies of apprenticeships. The culmination of this review is a set of recommendations.

Chapter 2 A Vision for educating engineering technologists

This chapter examines our end point, which is developing an engineering technologist equipped to deal with the challenges of the future. We explore the role of an engineering technologist and consider current thinking on the attributes required to equip such a person for roles in a future economy. We also investigate suitable teaching approaches for preparing students for engineering careers.

What is an engineering technologist?

Before we try to answer this question it may be helpful to try to ascertain what engineers do. This is actually quite a difficult question. Some commentators define engineers as a person who designs, builds, produces, etc. some artefact. Considering the global challenges that face us, and that engineers play an important part to help meet them, these terms do not encapsulate the complexity and breadth of the discipline. However, Trevelyan (2014), p9 provides a more comprehensive description:

> *"Engineers seek to understand, discern, and explain the needs of a client, firm or community in terms of engineering possibilities.*
>
> *Engineers conceive achievable economic solutions and forecast their performance, benefits, and costs to help with investment decisions.*
>
> *When investors decide to proceed, engineers arrange, organise, and manage the predictable delivery, installation, and operation of reliable artefacts (man-made objects, material, and information systems).*
>
> *Engineers think ahead to reduce or eliminate risks and uncertainties that could have negative consequences. While many events are intrinsically unpredictable, engineers can help to make sure that negative consequences are minimal or at least reduced as much as possible"*

Trevelyan also acknowledges that engineering relies on a multitude of specialist knowledge that is held (usually unwritten) in the minds of people collaborating with one another. The career options for the broad spectrum of engineering occupations are:

Engineer

Technologist

Associate or Technician

Tradesperson

The 'professional tracks' of engineering usually begins by undertaking some form of initial education and training. In addition, if the person wishes to become part of the profession at large, and be nationally and internationally recognised, they must seek to study for qualifications that are accredited by the various national signatories of the International Engineering Alliance (IEA), e.g. IPENZ is NZ's signatory. IEA (2013) specified 12 graduate attributes that an engineering qualification must deliver through its curriculum, teaching and assessment at the end of a student's study.

Each of the 12 attributes is differentiated by the characteristics of three 'tracks' of engineer namely engineer; engineering technologist and engineering technician described in parenthesis (). These attributes are: 1) Engineering knowledge (complexity of problem) 2) Problem analysis (complexity of analysis) 3) Design/development of solutions (breadth and uniqueness of engineering problems, i.e. the extent to which problems are original and to which solutions have previously been identified or codified) 4) Investigation (breadth and depth of investigation and experimentation) 5) Modern tool usage (level of understanding of the appropriateness of the tool) 6) Engineer and society (level of knowledge and responsibility) 7) Environment and sustainability (type of solutions) 8) Ethics (understanding and level of practice) 9) Individual and team work (role in and diversity of team) 10) Communication (level of communication according to type of activities performed) 11) Project management and finance (level of management required for differing types of activity) 12) Lifelong learning (preparation for and depth of continuing learning).

The IEA also distinguishes between the engineer; engineering technologist and engineering technician by using the notions of *complex engineering problems*, *broadly-defined engineering problems* and *well-defined engineering problems*. The initial qualifications taken by these engineers have been recognised as the programmes that satisfy the academic requirements for practice and are bound by the related Accord that specifies these requirements. These accords are for: the engineer – the Washington Accord; the engineering technologist – the Sydney Accord and the engineering technician – the Dublin Accord. Others, UNESCO (2010) and UKEngC (2014) have also distinguished between the three 'tracks' (Fig. 1).

ENGINEER	TECHNOLOGIST	TECHNICIAN
Typically those who will (UNESCO, 2010): • Use a combination of general and **specialist engineering knowledge** to optimise the application of **existing and emerging technology;** • Apply **appropriate theoretical and practical methods** to the analysis and solution of engineering problems; • Provide **technical, commercial and managerial leadership;** • Undertake the **management of high levels of risk** associated with engineering processes, systems, equipment, and infrastructure; and • Perform activities that are essentially **intellectual in nature, requiring discretion and judgement.**	**Typically those who will (UNESCO, 2010):** • **Exercise independent technical judgement** at an appropriate level; • Assume responsibility, as an individual or as a member of a team, for the **management of resources** and/or guidance of technical staff; • **Design, develop, manufacture, commission, operate and maintain products, equipment, processes and services**; • Actively **participate in financial, statutory and commercial considerations** and in the creation of cost effective systems and procedures; and • Undertake the **management of moderate levels of risk** associated with engineering processes, systems, equipment, and infrastructure.	**Typically those who will (UNESCO, 2010):** • Apply **proven techniques** and procedures to the solution of **practical** engineering problems; • Carry **supervisory or technical responsibility**; • Exercise creative aptitudes and skills within **defined fields of technology**; • **Contribute to the design**, development, manufacture, commissioning, operation or maintenance of products, equipment, processes or services; and • **Create and apply safe systems of work**.
UKEngC (2014) adds: …develop solutions to **engineering problems using new or existing technologies,** through innovation, creativity and change and/or they may have **technical accountability for complex systems with significant levels of risk.** They are able to demonstrate: • Theoretical knowledge to solve problems in new technologies and develop **new analytical techniques;** • Accountability for project, finance and personnel management and managing trade-offs between technical and socio-economic factors; • Skill sets necessary to **develop other technical staff;** • Effective interpersonal skills in communicating technical matters.	**UKEngC (2014) adds:** ….**maintain and manage applications** of **current and developing technology**, and may undertake engineering design, development, manufacture, construction and operation. They are able to demonstrate: • Theoretical knowledge to solve problems in **developed technologies using well proven analytical techniques**; • Successful application of their knowledge to deliver engineering projects or services using **established technologies and methods**; • **Effective interpersonal skills** in communicating technical matters; • **Commitment to professional engineering values**.	**UKEngC (2014) adds:** ….apply proven techniques and procedures to the solution of practical engineering problems. They are able to demonstrate: • **Effective interpersonal skills** in communicating technical matters; • **Commitment to professional engineering values**.

Figure 1: Engineering Professional Tracks

Whilst the description of professions is focused on what engineers must be able to do, a more holistic view of engineering has been developed to describe the ways in which engineers think. Lucas et al. (2014) in partnership with the Royal Academy of Engineering worked with engineers, to describe this thinking, which they've termed "learning habits of mind" visualised in Figure 2.

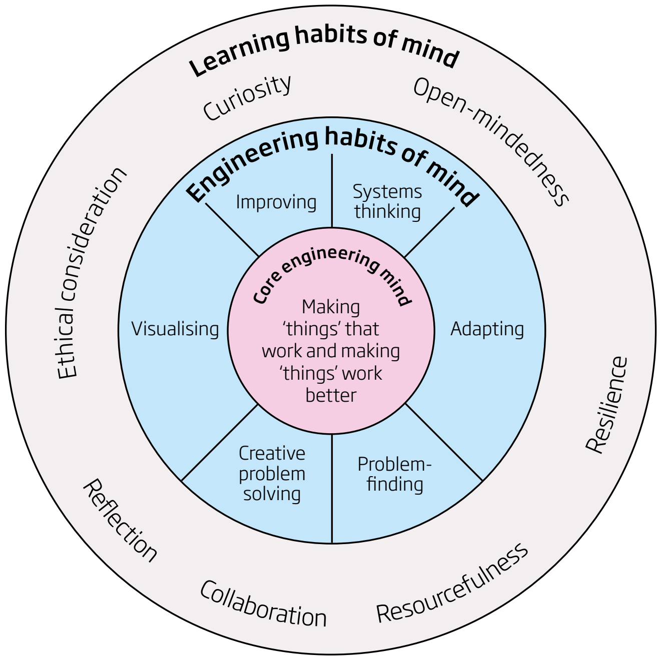

Figure 2: A Model of Engineering Habits of Mind (Lucas & Hanson, 2014)

With this model they challenge the engineering teaching and learning community to consider redesigning engineering curricula (at all levels from primary to tertiary) starting with the premise of cultivating learners to think like engineers, i.e. systems thinking, adapting, problem-finding, creative problem solving, visualising and improving.

Essentially the engineering technologist plays an important role in the practice of engineering. Depending on the complexity of the project they may work under a professional engineer as part of a larger team or may head up a team of technicians and other disciplines. They work at the boundary of current and emerging technologies and are critical to the successful delivery of engineering projects. They must possess a wide range of skills and competencies; not only in the technical domain but also in the critical socio-technical domain (Faulkner, 2007; Fletcher, 1999).

Equipping graduates for the challenges of the future

One of the first stages in an engineer's career is to obtain a qualification that prepares him/her to enter engineering practice as a technologist. Thus, it is important that the providers of tertiary study develop curricula and programmes that adequately prepare prospective engineers for entry to the profession, i.e. typically a Bachelor of Engineering Technology (BEngTech, NZQA level 7) in NZ.

This section outlines the theories of engineering educators on how to educate engineers for the 21st Century. We begin with outlining work conducted by leaders in the field of engineering education who have highlighted what educators must consider in order to develop well-rounded graduates. Although this work is focused on advising educators, it is also important that employers understand what is expected from the educators.

The United States' National Academy of Engineering (NAE, 2005) examined engineering education in the broadest context (i.e. it considered all the diverse branches of engineering at Bachelor of Science and Master of Science (M.S.) levels - recognising the M.S. degree as the "professional" degree) and identified what is needed to "enrich the education of engineers who will practice in 2020". This study encapsulates the challenges and complexity of the "societal, geopolitical, and professional context within which engineering and its new technologies will exist" and states that engineering education needs to adapt to ensure that the next generation of students is well equipped for such challenges. Engineering education can only adapt by ensuring that there is "interaction of engineers in industry and academe."

With regards to advising 'how' educators and industry can adapt to these challenges the NAE study suggests that there needs to be a:

1. "Better alignment of engineering curricula and the nature of academic experiences with the challenges and opportunities graduates will face in the workplace, and
2. Better alignment of faculty skill sets with those needed to deliver the desired curriculum in light of the different learning style of students"

Whilst the authors agree with the NAE's two points, this review will focus on the first point as our terms of reference do not extend to making recommendations about academic appointments. However, we will return to the theme of different student learning styles.

In 2010, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) commissioned a extensive landmark report on engineering recommending that engineering education, curricula and teaching methods undergo a significant transformation to "emphasize relevance and a problem-solving approach to engineering." This call echoes NAE's first point.

Some educators are focussed on developing engineering curricula that are 'better aligned' for the challenges they will face in their working career. For instance, the work of (Bankel et al., 2003) created an extensive 'codified' method for developing an engineering curriculum that builds on:

1. Technical knowledge and reasoning;
2. Personal and professional skills; and
3. Interpersonal skills.

Bankel et al. (2003) proposed that "graduating engineers should be able to Conceive-Design-Implement-Operate (CDIO) complex value-added engineering systems in a modern team based environment." The CDIO movement has been implemented across the globe in various degrees. It acknowledges the importance of creating graduates that have more than just technical prowess. For nearly 15 years the CDIO movement has been well regarded in the engineering education fraternity. Although this 'rounded' curriculum has been implemented by a number of universities across the globe, it still remains an uncommon phenomenon in most countries. For example, the UK has 9 CDIO member schools out of approximately 100 potentially eligible engineering schools (CDIO, 2015; UCAS, 2015).

(Adams et al., 2011) also challenge engineering programme leaders and designers to consider a more 'rounded' curriculum. Whilst the CDIO movement has focused on what engineers do to create well designed engineering systems, Adams et al. suggest widening the curriculum further to also include the transdisciplinary nature of engineering practice across complex "science-human-design-craft" dimensions viewed through a lens of social justice, class or gender.

NAE's (2005) examination of engineering education (at technologist and professional levels of engineering) reiterates the call for similar developments in engineering programmes:

- Adding tangible engineering experiences early in the curriculum, including team-based design-build-test projects and community service projects;
- Develop professional skills by exposure to innovation and invention that requires strong interdisciplinary, communication and team skills;
- *Utilise the advances of technology to enable learning, particularly fostering life-long learning as students become adept with blended, distance and asynchronous learning;*
- Ensuring flexibility for what a student wishes to pursue as a career.

A more recent comprehensive review of engineering education (UNESCO, 2013) so reaffirms NAE's calls for what should be developed in an engineering programme. UNESCO propose "that while aiming to assist students to achieve each of the Washington Accord graduate attributes, (engineering education programmes) should contain the elements necessary to provide the following" (p.126):

- A motivational foundation.
- An engineering project stream that will incorporate broad system engineering projects which introduce students to the breadth of engineering activities, provide opportunities to develop the general engineering attributes, include team and individual projects, be based on project based learning principles, and include design projects.
- A broad knowledge of engineering and its technological fundamentals and principles.
- A familiarity with mathematical tools sufficient to understand engineering fundamentals and to obtain solutions to engineering problems.
- Knowledge of the scientific principles, theories and relationships which are necessary to understand the technological issues associated with engineering.
- The capability to utilise information technology effectively to obtain information and to communicate, compute, design, simulate and model, in relation to the development and implementation of engineering solutions and systems.
- The development of a detailed technological knowledge in a specific field of engineering, and the ability to utilise it to solve engineering problems creatively.

- Experiences that provide insight in to the social, business, environmental, leadership, ethical and personal issues that are involved with working in an engineering project team.
- The development of communication and presentation skills in various situations.
- Development of the ability to be an independent life-long learner."

Essentially, engineering education should prepare students for engineering practice in the real world. Accrediting bodies and leading engineering educationalists have articulated that education must provide a more rounded experience to develop capabilities to cope with the future challenges and complexity that the practice of engineering will encounter such as (NAE, 2005): population growth (its impact on access to water and housing); a global economy (outsourcing of engineering jobs, and a need for interdisciplinary approaches); the steady integration of technology in public infrastructures (requiring engineers to participate in setting public policy). (Litzinger, Lattuca, Hadgraft, & Newstetter, 2011) state clearly what is required: "engineering education should encompass a set of learning experiences that allow students to construct deep conceptual knowledge, to develop the ability to apply key technical and professional skills fluently, and to engage in a number of authentic engineering projects."

The following section reports literature describing appropriate learning methods for achieving meaningful learning experience.

Effective learning methods and challenges ahead

There is a general consensus that students' learning should encapsulate deep learning and understanding. Also, there should be a move away from traditional lectures where students are passive receivers of knowledge and only experience surface learning. Examples of teaching methods that have been developed to encourage deeper learning experiences include problem-based or project-based learning (PBL) (UNESCO, 2010); group discussion; field trips; reflective diaries; peer mentoring; student class presentations; buzz groups or think/pair/share (i.e. short discussion in twos); role play, etc.

Intelligences and modes of learning

H. Silver, Strong, and Perini (1997) proposed the integration of multiple intelligences (MI) theory with learning styles. Coffield et al. (2004) in an extensive review of learning style literature, highlighted the critical relevance of learning styles to higher education. Gardner (1983) originally proposed 7 types of intelligence – a seminal proposal that has received wide support from subsequent researchers (Campbell, Campbell, & Dickinson, 1996; Gardner & Hatch, 1989; H. F. Silver, Strong, & Perini, 2000).

The significance of learning style and multiple intelligence theories is that traditional teacher-centred learning methods exclude potentially excellent engineers whose personal attributes work against them learning in a classroom environment. Conversely richer learning environments (i.e. problem-based, project-based or work-integrated situations) are arguably suited to a wider range of students, especially those attracted to engineering careers.

Litzinger et al. (2011) discuss 'effective learning experiences' that support the development of expert professional practices for engineering students. In particular, Litzinger et al. highlight the importance of PBL, an approach that is gaining momentum through engineering curricula around the globe; noting Aalborg University, Franklin W. Olin College of Engineering, and the University of Queensland as examples of integrating PBL in to the curriculum. The PBL approach has been widely supported in engineering education literature, with rigorous studies demonstrating learning advantages over directed teaching approaches such as lecture style delivery (Salas, Segundo, Álvarez, Arellano, & Pérez, 2014). It has been established as a teaching pedagogy at least since the mid-80s. Whimbey (1980) reported its early application in engineering and physics programmes at the University of Massachusetts. PBL first became established in medical training programmes (Barrow, 1986). Savery and Duffey (1996) report the three essential elements as:

1. Understanding is in our interactions with the environment
2. Cognitive conflict or puzzlement is the stimulus for learning and determines the organization and nature of what is learned.
3. Knowledge evolves through social negotiation and through the evaluation of the viability of individual understandings.

PBL relies on replicating the thinking processes required in the environment the learner is preparing for.

This is emphasized in the 2010 UNESCO report where they report that PBL is one educational solution due to its active learning process as it creates “motivation and, hopefully, an improved retention rate.”

Lucas et al (2014) explain that ‘messy’ approaches such as project-based and problem-based learning are effective methods for building engineering habits of mind. Lucas et al. (2014) describe these as “signature methods” which together create signature engineering pedagogies.

Whilst the focus here is on engineering education, New Zealand educational establishments ranging from Ministry level to teaching institutions have adopted the findings of John Hattie and Gregory Yate’s highly cited mega-analysis (analysis of meta-analyses) (Hattie & Yates, 2014). Hattie requires learning to be visible to both teacher and learner. That is, both the teacher and the learner have to be able to identify learning as it occurs. Learning is represented as an interactive process in which teacher and learner receive feedback from each other (Terhart, 2011). Although Hattie explicitly challenges constructivist approaches such as PBL, we consider that so long as due care is taken to incorporate the principles of visible learning, the problem-based, and project-based approaches remain valid and effective.

Hattie does however reject the concept of “teacher as facilitator of learning”. This arguably obsolete concept arose as the pendulum of educational thinking swung away from didactic teacher-centred delivery to the opposite extreme of a student-centred approach (O’Neill & McMahon, 2005). Hattie found that an ideal learning environment is an interaction between teacher and learner – a feedback system. This new understanding has critical consequences for the manner in which work-based experiences are delivered to students. Any programme in which the student is simply placed in a work environment and expected to learn has to be considered inferior to programmes that incorporate explicit learning intentions and active feedback.

Excellent feedback is a vital feature of effective programmes (Hattie & Yates, 2014). The precision and immediacy of feedback, and the subsequent visibility of learning do vary significantly bet ween delivery models – from the precise immediate feedback of supervised apprenticeship activity (Fillietaz, 2013) to post-placement feedback and self-reflection following internship or practicum reports. No single learning situation is ideal for learning all types of skills; while direct supervision may be ideal or even essential for learning complex manipulative skills, soft skills may be best learned through a rhythm of didactic delivery, activity and reflection. This reinforces another recurring theme – that there is no “one size fits all” solution. Effective learning can occur in a range of models.

So far we have focused on the range of learning methods to achieve deeper learning. We now switch our focus onto the challenges of implementing such methods.

Educators that have experience of instigating change in an engineering programme (such as one of the authors) acknowledge that change in curriculum and learning methods and assessment is extremely difficult at a programme level. Typically there is a resistance to change “especially in education where the dominant paradigm remains staff-centred teaching” (UNESCO, 2013).

UNESCO (2010) urge that educationalists should move towards more effective learning methods but acknowledge that few institutions “a very low percentage” have really changed to new instructional models. This current state of engineering education is also echoed by King (2012) who states that “there are some early signs of progress …, but they are limited.” UNESCO (2013) also reiterates the difficulty of changing engineering education practice and confirms that these calls for transformation “have not resulted in the necessary changes by the universities.”

So far we have outlined a set of desired attributes in graduates, and a set of common features in effective learning models. Together, the attributes and models constitute the drivers of a signature engineering pedagogy, and inform the design and development of suitable models at the engineering technologist level specifically, but also at the level of the technician and professional engineering tracks.

Experience-led learning is essential

This section outlines the body of literature that calls for greater industry engagement in the development and implementation of engineering curricula.

Alpay and Jones (2012) state that there is a need to ensure the curriculum allows for more student workplace skills development but another facet for attention is the need for stronger employer engagement in teaching. Whilst educationalists recognise that employer engagement incentives require some thought to bring about stronger interaction, greater engagement is likely to result in a win-win scenario for the employer and educator.

There is a longstanding tradition of employer involvement in engineering education, but the level of involvement or engagement has varied. A best practice example was the 2006 winner of USA's National Academy of Engineering 'Bernard M. Gordon Prize for Innovation in Engineering and Technology Education' with their Learning Factory concept (Lamancusa, Zayas, Soyster, Morell, & Jorgensen, 2008). The concept is dedicated to industry-partnered, active learning and was "founded on three beliefs: lecturing alone is not sufficient; students benefit from interactive hands-on experiences; and experiential, team-based learning involving student, faculty and industrial participation enriches the educational process and provides tangible benefits to all." Beginning in 1994 it has involved three universities (Penn State, University of Puerto Rico-Mayagūez, University of Washington), 1,200 sponsored design projects; US$10M in external support; over 200 industry partners; and over 10,000 students.

In the UK, the Royal Academy of Engineering (RAEng, 2015) has strongly recommended that "industrially relevant course content and opportunities for students to gain work experience should be integral within every undergraduate engineering course and therefore **more widespread adoption of experience-led engineering must be achieved**". This statement is intensified by RAE's call to action of "experience-led teaching is, in our view, a vital component of educating the best engineers to support all these aims and needs to be embedded and supported as a matter of priority." This extensive report focused on how to encourage universities (i.e. the education of technologist and professional engineers in the UK) to develop programmes that include "experience-led" teaching, designed and delivered mainly in partnership with industry and business. It includes 15 exemplars of experience-led teaching and it is clear that there are numerous methods to achieve some very positive results. The findings identify eight key parameters that help universities achieve greater levels of experience-led teaching:

1. One size doesn't fit all – universities must take their own approach.
2. Experience counts – students need worthwhile work experience integrated within their degree.
3. Relevance motivates – students are motivated and engaged by industrially relevant course content and should be integral within every undergraduate engineering course.
4. Change needs champions – learning and teaching champions that have experience of industry must be supported.
5. Responsibility must be shared – both industry and universities must commit to championing enhancements to experience-led engineering degrees
6. Management leads change – change must be aligned with institutional strategy and requires senior management support.
7. Resources matter – new teaching methodologies require appropriate learning spaces, equipment and supporting technologies.
8. Financial sustainability – the introduction of experience-led components into engineering degrees will require start-up and/or capital funding.

The UK report also highlights the significant barrier involved in obtaining industry engagement with the tertiary sector. This is associated with costs, particularly with respect to staff time. The report suggested an expansion of the current R&D tax credit scheme to enable companies to claim for time spent on university engagement activities; donation of equipment or payroll expenditure on placement students.

The emphasis to engage industry in engineering education has also been discussed at governmental level in Australia, within a larger context of examining "the nexus between the demand for infrastructure delivery and the shortage of appropriate engineering and related employment skills" (Senate, 2012). The committee's view is that "practical work experience provides benefits to industry, government and students" and encourages models such as the Australian Power Institute bursary program, sponsored by companies in the power industry, to be used to create paid work experience for engineering students. The advice of this committee prompted the Australian Council of Engineering Deans (ACED) to sponsor a project to develop "guidelines to strengthen the culture of industry engagement in engineering education in Australia" (ACED, 2014). These guidelines are illustrated in Figure 3 and essentially call for educators, industry and government and professional bodies to integrate their activities to support industry engagement.

ENGINEERING FACULTIES	INDUSTRY	PROFESSIONAL, INDUSTRY BODIES AND GOVERNMENT
• Faculties establish/maintain effective industry engagement as part of faculty culture • Programmes use industry-based assignments • Students have substantial opportunities to learn and work in industry • Student undertake industry-based final year projects • Students encouraged to learn about practice • Faculties recognise industry engagement undertaken by student groups	• Organisations provide regular & structured employment • Employers provide support for their engineers to engage with education • Employers provide support for academics to experience industry	• Industry, universities, student societies & Australasian Association for Engineering Education establish a resource centre to support industry engagement with universities • Government, professional bodies & faculties establish a joint internship scheme • Engineering Australia (EA) develop e-portfolio for students • Industry bodies establish & support engagement • EA review accrediting guidelines regarding engineering practice

Figure 3: Best Practice Guidelines to increase industry engagement (ACED, 2014)

What is also clear is that there is no 'correct or right way' to undertake industry engagement and that many tertiary institutions often use a multitude of experiences. For example, Figure 4 outlines the many examples of best practice that were investigated.

RAE (2010)	ACED (2014)
Direct Experience: Industrial placement year (sandwich course) Other industrial work opportunities Relevant employment for part-time students Relevant student-led activity	**Direct Experience:** Vacation employment (internships) Faculty staff teach into in-house units for engineers in an industry organisation Industrialists employed as Visiting Professors
Indirect Experience: Industrial simulation (constructionarium and pilot plants) Project-based learning and other forms of active learning Industrial group projects, design projects, multidisciplinary projects Case studies from industry Influence of part-time and mature students on full-time students Site visits and field trips Entry to national and international competitions (i.e. Formula Student) Student involvement in professional institutions.	**Indirect Experience:** Emulated work-integrated learning Units/modules/papers taught by engineers & with engineering practice integrated into unit Guest lectures Lunchtime panels Mentors schemes Industry Expos NB: The ACED examples are in addition to the RAE example

Figure 4: Examples of Industry Engagement in Engineering

Conclusion

There is general consensus that industry engagement is an essential component of learning programmes in order to achieve the broad range of skills, knowledge and attributes needed to enable engineers to face the challenges of the future. Industry engagement should take the form of widespread consultation and collaboration between tertiary education providers, industry representatives and industry accreditation bodies in the design, delivery and ongoing revision of engineering education courses.

There are many models of industry engagement, all of which have merits. There is no "one size fits all" solution. Different industries need to develop models that work for their business environment. There is a well-established body of knowledge describing suitable methods for teaching engineering. The most prominent of these is problem or project-based learning. More recent literature focusses on feedback and visibility of learning. Effective learning methods combined with industry engagement are essential to develop engineers for the future.

Chapter 3 Experience-led learning models – common themes

Many learning models involving employers can be described as experience-led (Royal Academy of Engineering, 2010). There are also many right ways of attaining experience-led learning as 'one size doesn't fit all'. For this study we've distinguished these models based on the focus of learning and by considering if the learning programme is driven by an educational institution or by an employer; refer to Figure 5 adapted from DeClou, Sattler, and Peters (2013) p9, and (Vaughan, 2012) p7. We have placed the models based on the level of employer involvement, with 'apprenticeships' having the highest employer involvement and 'projects' the least. This is not an exhaustive list of terms/models used to demonstrate employer involvement.

DRIVER AND PLACE OF LEARNING	EMPLOYER DRIVEN PREDOMINANTLY WORKPLACE-BASED	EDUCATIONAL INSTITUTION DRIVEN PREDOMINANTLY EDUCATION INSTITUTION-BASED			
EXPERIENCE-LED MODELS	**Apprenticeships**	**Co-op** **Sandwich**	**Internships** **Cadetships**	**Practicum**	**Projects**

Figure 5: Experience-led learning models

Common themes within these models are presented here as essential components for the development of effective engineering technologist education.

Convergence – educators and employers step into one another's world

Bill Lucas and others, in a series of papers (Lucas & Hanson, 2014; Lucas & Spencer, 2015; Lucas, Spencer, & Claxton, 2012), provide the clearest guidelines for the design and delivery of effective experience-led learning models, focusing mainly on apprenticeships. These are summarised by:

- Collaboration between educators and employers
- Early engagement between students, employers and educators
- A deliberate integration of situated and disciplinary knowledge
- Rejection of "one size fits all" approaches
- Clear pathways from school to employment.

Even though we have been tasked with focusing on employment-centred delivery of engineering learning, it is important to note that the ownership of a programme is not the primary determinant of its effectiveness. True determinants of success include the extent to which educators and employment providers collaborate on programme design and delivery, and the timing and extent of their engagement with students. The authors of a wide-ranging international study (Mourshed, Farrell, & Bartob, 2012) put it thus:

> *"Innovative and effective programs around the world have important elements in common. Two features stand out among all the successful programs we reviewed. First, education providers and employers actively step into one another's worlds. Employers might help to design curricula and offer their employees as faculty, for example, while education providers may have students spend half their time on a job site and secure them hiring guarantees. Second, in the best programs, employers and education providers work with their students early and intensely. Instead of three distinct intersections occurring in a linear sequence (enrolment leads to skills, which lead to a job), the education-to-employment journey is treated as a continuum in which employers commit to hire youth before they are enrolled in a program to build their skills."*

Another common theme in effective learning programmes is the deliberate integration of situational (work-based) skills with academic knowledge. Vaughan (2012) reports that: "…all occupations now require constant adaptation and knowledge development, and this is best undertaken through a thoughtful combination of theory and practice, expressed/developed in, and connected across, different settings." She argues that this requires a mix of situated and disciplinary knowledge. The terms "convergence" and "complementarity" describe a merging or overlap of vocationally delivered programmes and higher education. Successful models that achieve this convergence and complementarity include programmes as culturally and geographically disparate as Ontario's Waterloo University co-op model (DeClou et al., 2013) and the *fachhochschulen* of Austria (Archan & Mayr, 2006). Before continuing with our discussion of recurring themes, such as convergence, we examine a selection of models.

THE CANADIAN CO-OP MODEL

The term "co-operative" or "co-op" is widely used in tertiary education literature to describe a range of work integrated models such as sandwich models. The alternative term "placements" conveys an implication of ownership by the learning institution – a sense that the term "co-op" avoids in favour of a sense of co-ownership by work provider and tertiary institution. The Canadian model (specifically Waterloo University) is characterised by students alternating semesters between work and tertiary institution. These relatively short placements were positively regarded by both students and employers surveyed by Kramer and Usher (2011) and can be argued to constitute good, if not best practice.

Kramer and Usher (2011) examined the benefits of various models of Work-integrated Learning (WIL) in Canada and found the co-op model to be the most beneficial system to both student and employer. Other structures, notably research assistantships and internships were also reported to be beneficial. The co-op model was reported to be particularly suited to engineering students where the nature of the work related closely to the field of study. Walters and Zarifa (2008) reported that co-op programmes helped ease transitions from school-to-work. Their research suggests that the Canadian model of co-ops may constitute a mechanism for breaking down prejudice against groups who have been traditionally under-represented. In New Zealand under-represented groups in engineering and technical fields (e.g. Māori, Pacifica and Women) may benefit from a co-op model. This co-op model was reported to increase employers' confidence that a graduate has a wide range of desired employability traits.

DUAL SYSTEMS

Gōhringer (2002) describes the German system as a dual system. Young people enrolled in the dual system are both students and employees. The company's investment risk in students is balanced by their status as equal partners, exerting "a continuous and important influence on the learning institutions' organisation and curricula" (Gōhringer, 2002). A factor in the model's early development was the involvement of three global companies (Bosch, Daimler Benz and Standard Electrik Lorenz). A current example of a dual system institution, the Berufsakademie Karlsruhe, has 900 participating companies training 1800 students (one third engineers). This data is useful in providing a guide for the required ratio (about 1:2) of participating companies to students. A remarkable (but not unique) outcome of this model is that around 85% of engineering students remain in permanent employment in the company in which they trained, however, the extent to which this data is relevant to the SME-dominant NZ environment remains uncertain.

Similar systems are described elsewhere in Europe; the Scandinavian and Swiss models frequently being described as successful or good practice in vocational education literature. A common factor is that these experience-led models are embedded in their entire education systems, and are therefore not easily transferable to NZ. We go on to examine the Austrian model, as despite lacking transferability (as copying it would require changes to our entire education system), it has some unique and interesting features, and exists in an economy of a comparable scale to New Zealand.

THE AUSTRIAN MODEL – AN APPRENTICESHIP MODEL

The Austrian model of Vocational and Educational Training (VET) is highly successful in that 80% of young people opt for one of the various versions of VET after completing compulsory schooling (Archan & Mayr, 2006). It is characterised by early, high level differentiation (at age 14) enrol in vocation education colleges that provide skill certification and access to higher education. The dual apprenticeship / school-based VET models result in low levels of youth unemployment.

Other features of the system include social partners e.g. co-operative associations between associations of employers and employees based on voluntarism. Some of these partners exert influence at all levels through to Government policy, and have close association with political parties, and some are (private) providers of VET education.

Fachhochschulen are institutions set up (from 1994) to provide practice-orientated tertiary level courses. These institutions are set up by independent provider bodies (mostly private sector). While their ownership is not prescribed, the accreditation of their courses is overseen by a supervisory body. The Austrian model is characterised by carefully designed supporting, funding, administrative, accreditation, representative and co-ordination structures, resulting in flexibility and permeability in courses and relevant qualifications at the student level.

Practical work experience is a requirement of these courses, and apprenticeships are offered in almost every area of economic activity. An innovative component of this training is *Ubungsfirmen* (UFA) or practice firms. These are modelled on real firms and have real business partners in industry and commerce. Students from a range of disciplines can experience real work situations in these UFA. The advantage from a learning perspective is that appropriate pedagogical practices can be embedded in real work situations.

Lucas and Spencer (2015) argue that the apprenticeship model offers a unique combination of social, economic and moral benefits. It serves employers by delivering an employee mind-set characterised by openness to lifelong learning, and achieves the learning principles discovered by recent researchers.

LESSONS FROM THESE MODELS

An important lesson from these models is that co-ownership, co-development and co-delivery are preferable as high-level approaches to either "institution-led" or "employer-led". The Canadian experience indicates a preference for semester length co-op placements, but shows that a range of delivery modes can be effective. The Austrian system is certainly commendable and deserves further attention, but it doesn't lend itself readily to replication in New Zealand in that it is a fully integrated education system, imbedded in that society and culture. However some features could be taken as exemplars for re-development within the New Zealand system.

The Austrian UFA or practice firm concept for example may constitute a mechanism for working around the issue of New Zealand's preponderance of SMEs (i.e. companies without the resources or needs of the large companies that have initiated vocational programmes in the UK and Europe). Structures mimicking Austria's co-operative associations and partnerships, but fitting our socio-political environment could be developed.

There are issues and barriers that have to be addressed to achieve collaboration between educators and employers. UNESCO (2015) sums up these issues:

- "The availability and willingness of suitably qualified industry representatives to work in such areas cannot simply be assumed. Equally, getting the right quality of employer representatives appointed to governance structures, and getting them to work well in concert with educational professionals and other stakeholders, is a complex challenge.
- There is a danger that the collective voice of employers is often that of larger enterprises and better organized sectors, with the voices of small, micro and informal enterprises too often neglected.
- In workplaces responsiveness to multiple stakeholder networks is not simple. Managers making training decisions are often not owners, and may have their own vested interests.
- Individual firms' rationality regarding investment in skills may not aggregate to national needs.
- A tendency for decisions about vocational education in firms to be driven by short-term concerns that is not sufficient for the firm or the nation to achieve and sustain international competitiveness in the longer term."

Clear pathways and progression

A recurrent theme in vocational education literature is the need for clear pathways – education choices that lead to employment. Mourshed et al. (2012) report 2008 OECD data that place New Zealand youth 22nd out of 32 in terms of NEET (not in education, employment or training), and males lowest (of 29 surveyed OECD states) in terms of the perceived value in pursuing tertiary study (reported as "net present value of tertiary education"). Lack of clarity in the outcomes of various pathways is listed as a contributing factor. Mourshed et al. focus on confused transitions in stages of education and report misalignment between the perceptions and expectations of all three major stakeholders: students, employers and educators. In stark contrast, the effective Austrian model (Archan & Mayr, 2006) is characterised by early differentiation into distinct career pathways but with "permeability" between those pathways, including bridging courses where necessary. In that model, school and tertiary curricula are continuously revised to ensure relevance and compatibility. In Austria, vocational training is highly regarded; all VET programmes exceeding two years lead to an entrance qualification to higher education. By whatever means these pathways are achieved, clear and flexible transitions between school, vocational education and higher education leading to reliable employment opportunities are essential components of successful engineering education programmes. This blurring of the boundaries between academic and vocational education (termed hybridisation) is an international trend that is becoming more pronounced, with more overlaps and interconnections between employers and education providers (UNESCO, 2015).

This "hybrid" approach is yet another response to the need to integrate academic and vocational learning. It is expressed elsewhere in this report as a need for educationalists to actively move into the employers' space, and vice versa.

Conclusion

The call to step into each other's worlds is a call to break down barriers between employers and tertiary teaching institutions. This is a challenge – requiring a commitment to work through difficulties.

When considering employer involvement we have to separate course delivery from course planning and design. Suitable models for employer-led learning vary in terms of levels of involvement in the **delivery** of courses (Fig. 5), ranging from apprenticeships which have the highest level of employer involvement through co-ops and practicums to university projects that may only involve employers as advisors. However, we have concluded that a high level of employer involvement is essential in the **planning and design** of all courses, whatever mode of delivery is preferred. The models in which employers have greater involvement in the delivery (i.e. apprenticeships and co-ops) are generally regarded as providing more reliable outcomes in terms of the "work-readiness" of employees, but higher levels of employer involvement at the planning and design stage are supported unequivocally.

Successful models (such as the Canadian and Austrian models) have been actively developed over time to fit individual, social, and industrial environments. These models are not readily transferrable to NZ, although aspects of excellent models provide useful exemplars. The evolution of successful models is characterised by long-term collaboration, negotiation and commitment of education providers, employers and their representative bodies, Government and accreditation bodies.

Clear pathways from school, through various levels of certification through to higher degrees are essential aspects of excellent models. Students and their trusted advisors need to understand that early career choices are open-ended, and can lead to fulfilment of personal goals. Where clear pathways exist, vocational education attains higher status and is perceived as a desirable option by young people.

Chapter 4 Apprenticeships - A renaissance

A recurring issue highlighted in engineering education literature is that employers are dissatisfied with the "work-readiness" of graduates and that graduates of any programme require a broader skillset than technical skills or academic knowledge; broader even than the combination of both (Mourshed et al., 2012). The essential skills required are wide-ranging and difficult to define, but include professional skills such as ability to work in teams and the ability to continue to learn. We have also highlighted the need for educating engineers with active engagement from employers, i.e. experience-led learning, is essential for developing the breadth of skills required.

From here we focus on the apprenticeship model. We acknowledge that other models effectively involve varying degrees of employer engagement. However, we have been commissioned by the Tertiary Education Commission to specifically focus on apprenticeships, to ascertain whether apprenticeships might be appropriately used to educate engineering technologists in New Zealand.

Apprenticeships in the spotlight - A response to drive economic growth

Most economies strive to ensure that the education of people (at all levels and ages) positively support the economy now and will continue to do so in the future. This is particularly relevant for countries that are basing economic growth on developing businesses that can compete internationally in the high-value, technology-based markets. Such businesses require a workforce that are technologically proficient and can adapt, develop and grow their skills.

Engineers are crucial to driving economic growth, with many countries focusing on developing engineering capacity as a growing contribution to support their economies. The UK's Royal Academy of Engineering (RAE) is currently leading the Engineering for Growth (EfG) campaign to demonstrate the 'contribution of engineering to economic growth and the quality of life' to influence public support for the engineering sector and to help reduce the skills shortage. RAEng (2015) reports that the UK will require "1.28m new science, engineering and technology professionals and technicians by 2020." In Australia, a Senate inquiry was set up to address the shortage of engineering and related employment skills (Senate, 2012). The United States of America are calling for new policies to improve Science, Technology, Engineering and Mathematics (STEM) training throughout the U.S. educational system in the interest of their economy's recovery (AIC, 2013).

This focus on developing engineering skill capacity has prompted the U.S.A. and the U.K. to support initiatives that they believe can expand economic opportunity. There is now a resurgence of employers being actively involved in education, particularly with expanding vocational approaches of education such as apprenticeships. For instance the U.S. Department of Labor is financing $2 billion over 4 years for grants to develop and implement apprenticeship programmes (USDoL, 2015). It has also recently introduced the LEAP Act, S.574 (Leveraging and Energizing America's Apprenticeship Programs) to increase apprenticeships through a new federal tax credit for employers. Similarly, the UK government has pledged to invest £170 million over 2 years (to 2016) to encourage small businesses (i.e. those with fewer than 50 employees) to take on new apprenticeships and £20 million over 2 years (to 2016) to support degree level and postgraduate apprenticeships(DBIS, 2014).

These initiatives recognise that involving employers in education improve economic growth and also reduce inequality and youth unemployment.

This trend for increasing apprentices in the 'English speaking' world (i.e. Australia, Canada, Ireland, United Kingdom and the United States) has been supported by national reviews and reforms to ensure that the next generation of apprentices are not set back with the issues of the last decades (Bewick, 2015; Dolphin & Lanning, 2011; Guthrie & Dowling, 2012; Nash & Jones, 2013). Those issues include:

- low-status
- relatively low employer demand compared to e.g. Germany and Switzerland
- poor quality of content and too short
- focus on level 2 and 3 (initial qualifications)
- minimum time spent off-the-job
- skills mismatch leading to unemployment
- complex system.

UNESCO's recent 2015 global analysis on Technical and Vocational Education and Training (TVET) acknowledges that TVET is gaining momentum and topping policy agendas. Simply "scaling up current provision in its current forms is unlikely to prove adequate." Further development is required to ensure that vocational education meets the demands of the future.

While 'vocational education studies' typically relate to initial qualifications (i.e. NZQF 3 and below), there is acknowledgment that the concepts, ideas, and methods are also applicable for higher qualifications (UNESCO, 2015). UNESCO state that higher-level TVET programmes are more in demand because they improve vertical learning pathways, facilitate lifelong learning, and strengthen higher-level skills. Countries such as the Netherlands, the Republic of Korea and China have strong post-secondary pathways (i.e. transition into tertiary education). This trend for higher-level vocational education is also seen in the UK as degree apprenticeships are currently being developed and will be launched in September 2015 (SFA, 2015).

Reviving the appetite for apprenticeships

This section concentrates on what constitutes an apprenticeship in today's environment and how they are being encouraged as an effective learning model in many countries' educational systems.

> *Bewick (2015) provides a recent definition: "an apprenticeship can be defined as the existence of a legally enforceable work contract between an employer and an apprentice, which specifies, for a particular duration of time, what learning, on the job and off the job, the apprentice will undertake to become competent or fully proficient in a defined career or occupational role."*
>
> *Alternatively, an apprenticeship "is a job with significant in-built learning designed to prepare individuals for future employment, employability and active citizenship" (Lucas & Spencer, 2015).*

A NEW GENERATION OF APPRENTICESHIPS

The apprenticeship model is perhaps the oldest model of adult learning. It has roots in ancient and tribal cultures epitomised by the Japanese *Sensei/uchi-deshi* or the Hebrew *Rabbi/disciple* relationships. It is arguable that the apprenticeship model lends itself to the natural learning process of the human species by mirroring parent-child teaching.

Modern apprenticeships have evolved to fit an environment where the apprentice cannot learn all that is required from a single master, and indeed must learn new and evolving skills and knowledge that previous generations are unfamiliar with. Modern apprentices need to learn new skills that didn't exist during the apprenticeship period of their "masters". The modern apprentice will be taught by many "masters", some of whom may be virtual.

However, the heart of a modern engineering apprentice is the same as the ancient apprenticeships –learning the mind-set and attitudes of a profession; the culture of an organisation and the ability to continue to learn.

Despite the surface similarities between old and modern apprenticeships, there are significant differences between the traditional apprenticeship and the attainment of the skills, knowledge and attitudes necessary to function in and contribute to a modern engineering environment. The most valuable thing we can actually gain from the old model is an effective vocational pedagogy – an appropriate mechanism for learning.

APPRENTICESHIP AND OCCUPATION

The concept of occupation is extremely important in apprenticeship systems. Fuller and Unwin (2013) argue that "it's important to show that an apprenticeship is a model of learning for skill formation which takes the apprentice on a journey to becoming a full member of an occupational community. This means that each occupation has a defined knowledge-base and associated curriculum which has to be completed and examined in order for the apprentice to show that s/he meets the requirements to practice as a recognised member of the community." Fuller and Unwin support the German model which presents an "holistic picture of each designated occupation and its characteristics, which makes progression routes more transparent for prospective apprentices, employers, parents, careers guidance staff and other stakeholders." (Fuller & Unwin, 2013).

Therefore the model NZ implements to educate engineering technologists must be termed in the voice of the 'occupation' and should lead to clear programmes that develop individuals to work in the occupation.

(Bewick, 2015) summarises world class apprenticeships as having five core components:

1. An apprentice receives a paid work contract
2. Occupational standards of some description are used to determine the competence required to achieve mastery
3. Both on the job and off the job training is deployed as a learning model
4. Competence is verified through both employer and independent assessment, which could include third party or industry certification
5. International placement opportunities would be a unique feature of a world class system

The 'new generation' of apprenticeships are not only a mechanism for capturing some academically capable students who might otherwise pursue a career in pure science (effectively competing for the same pool of talent), but it is also a mechanism for capturing potential talent that the school system has failed to properly exploit. It provides a learning mechanism for students whose preferred learning style and modes of intelligence prohibits them from learning in classroom situations as well as an attractive proposition for academically able students with aptitude for engineering work. The apprenticeship model removes the 'disconnect' between learning and employment described by Mourshed et al. (2012).

Incentives for employers to get involved

Only 20% of UK firms with ten or more employees hire any apprentices compared to 51% in Germany (Nash & Jones, 2013). In Australia, 27% of surveyed employers engage apprentices and trainees (NCVR, 2013).

In response to such low levels of employer engagement, the UK government has pledged to support apprenticeships by: 1) developing advertising campaigns; 2) establishing a network of sector apprenticeship ambassadors; 3) educating business advisors to help promote benefits to clients; ensuring better data is available to enable employers and their apprentices to make informed choices; 4) implementing employer satisfaction measures (especially with education and training providers); 5) providing better apprenticeship destination data and improved data on the economic returns of apprenticeships.

Nash and Jones (2013) outline the following proposals to improve employer engagement in the UK:

- Provide incentives for employers, training agencies and pooling associations which include a £1,500 grant split between the small employer and pooling association, based on post apprenticeship employment rates
- Develop a tailored information campaign towards employers which would target businesses less likely to participate
- Provide sector skills council publications to market the benefits of dual vocational education and training, tailored by industry and size of business and include lessons learned from international best practice
- Create positive publicity for participating employers, such as introducing an employer badge certifying participation in apprenticeship programmes, publishing an annual list of top employers for employing apprentices alongside examples of successful apprentices and introducing a Department for Education/Department for Business, Innovation & Skills award for the best employer in various training and apprenticeship categories

- Create a nation-wide apprenticeship pooling system enabling small or specialist businesses[3] to share apprentices, thus creating more apprenticeship places and allowing more businesses to take part.

Other initiatives in the UK to improve apprentice uptake include:

- **Apprentice Graduation Ceremonies**
  Particular regions in the UK now provide apprenticeship graduation ceremonies. The Skills Funding Agency provides 60% of the costs (the remainder made up of sponsorship and local area funding). For instance in the East Midlands region, 500 apprentices attended an apprentice graduation ceremony (DerbyCollege, 2015).
- **National Apprentice Week**
  Events were held throughout the UK to celebrate apprenticeships and the positive impact they had on individuals, businesses and the wider economy. This culminated with 23,000 apprenticeship vacancies being pledged (HMGovernment, 2015d).
- **Employer Networks**
  Employers are taking the lead to improve skills in their sector. For example the Tech Partnership is focussed on creating skills for the digital economy. "We work to inspire young people about technology, accelerate the flow of talented people from all backgrounds into technology careers and help companies develop the technological skills they need for the future" (TechPartnership, 2015). Key members of this particular network are members of the Digital Technologies Trailblazer project and they actively promote apprenticeships to their network.

Similar actions that have been called for in the US (Olinsky & Ayres, 2013) include:

- Create a national apprenticeship website
- Convene a blue ribbon commission (i.e. to overhaul national system making it a more central mechanism for training workers for high-skill jobs)
- Leverage the federal workforce and federal contracting to support apprenticeships
- Improve marketing to business to encourage more industry engagement
- Offer funding incentives - (e.g. creating a $1,000 federal tax credit per apprentice with additional $1,000 per year for each apprentice under 25)
- Improve research and standards - (e.g. into costs and return on investment, to attract more women in the workface, rebranding, etc.)
- Facilitate small and medium-sized businesses establishing joint training programmes - (a suggestion where employers join forces to offer apprenticeships by establishing a trust fund to finance. An apprentice could be contractually prohibited from working for nonparticipating employers in that sector for a defined number of years. Alternatively, Congress may authorise a compulsory contribution to an apprenticeship trust fund for a particular sector).

Also, in Australia (AiGroup, 2013):

- Develop a clear and consistent definition of an apprenticeship to distinguish it from other programmes
- Establish a National Apprenticeship Commission to progress reforms to the Australian Apprenticeship system
- Re-focus apprenticeships to be 'Employer-Apprentice' centred
- Support competency-based progression and implement findings from the Accelerated Apprenticeships)
- Address apprenticeship completion rates
- Strengthen the pathways into an apprenticeship
- Continue employer incentives such as the *Kickstart* Employer Incentive bonus that offers $3,350 bonus, paid at the start of an apprenticeship)
- Promote Excellence through *Worldskills* and other programs which showcase apprenticeship achievements).

A recent report, commissioned by the Skills Funding Agency in the UK, demonstrates clearly the benefits of apprenticeships to businesses (Corfe & Kyriakopoulou, 2015):

- Apprentices are estimated to have resulted in a positive net gain to employers of on average £1,670 per apprentice in England in 2013/14.

[3] Small and specialist businesses may not be able to offer the whole range of experience necessary for a full apprenticeship

- Long-term productivity gains from apprenticeships were found to be highest in the engineering & manufacturing sector and the construction & planning sector, at £19,900 and £19,200 per year respectively.
- One in ten consumers surveyed said they would be more likely to visit a store and make a purchase if they knew that a business employed apprentices.
- 25% of consumers said that they would be more or much more likely to pay extra for goods and services offered by businesses and organisations employing apprentices.
- 67% of consumers agreed that offering apprenticeships is "a key part of a company's engaging with society".
- Employers report that apprenticeships bring other benefits – such as a better image in the sector, improved staff retention and improved staff morale.

In summary, there are currently many initiatives in place across the 'English speaking' world to address the barriers and issues that apprenticeships are facing. If we, in New Zealand, wish to consider apprenticeships as a viable, attractive learning model then we must also consider adapting these types of initiatives to our context.

A 'signature pedagogy' for engineering education

UNESCO (2015) claim that technical and vocational education and training (TVET) goes beyond improving economic competiveness, by being a "vehicle for social equity and inclusion". An important feature of this vehicle is a "focus on learning outcomes rather than inputs". UNESCO (2015) state "this shift is away from traditional TVET qualifications that are based solely on inputs such as subjects and hours of study requirements, to include a better identification of what the student is expected to have achieved by the end of the course of study. These achievements are organized in modules and expressed in terms of knowledge gained, skills learned, and competencies and aptitudes acquired." Lucas & Spencer (2014) report that European apprenticeship models are moving away from the provider to the learners and that policies are reflecting a "shift in thinking about the importance of learning outcomes".

We recognised earlier the call for employers to have greater influence in the design and delivery of engineering vocational training. While moving to an outcome-basis rather than a process-basis is important, it is equally important to consider the actual teaching process of an engineering apprenticeship. In this content, Lucas and Spencer (2014) caution that:

> "While simplifying structures and putting employers in the driving seat is essential, organising learning for an apprentice is a complex activity which requires an understanding of vocational pedagogy."

This shift to outcome focus (i.e. specification of the capability of person at the end of an apprenticeship) and a widening of apprenticeships (i.e. being more than just the development of routine skill) is summed up by Lucas & Spencer's (2014) six desirable learning outcomes of apprenticeships:

1. Routine expertise in an occupation.
2. Resourcefulness – the capacity to think and act in situations not previously encountered.
3. Craftsmanship – pride in a job well done and an ethic of excellence.
4. Functional literacies – numeracy, literacy, digital and graphical.
5. Business-like attitudes – customer and client-focused, entrepreneurial and aware of value for money, whether in for-profit, public sector or third sector roles.
6. Wider skills for growth – the disposition

Before discussing the learning process itself, we consider the environment in which this learning takes place. Factors within the workplace environment that affect the quality of learning include:

- The people - workplace experts, teachers and their personal examples of discipline and craftsmanship
- The physical location - the technology, the space
- The management approach - e.g. attention to continuous improvement and standards
- The business environment - e.g. a risk-averse environment such as aerospace or healthcare will entail different learning from innovative high tech environments
- The organisational culture.

The learning process

We have identified four key features of the apprenticeship pedagogy. This learning process is applicable to physical and technological tasks and processes, and is useful for teaching knowledge. The learning process is:

1. Cognitive; applying traditional craft apprenticeship values and methods to learning (Collins, Brown, & Newman, 1989)
2. Formative; assessment must be formative in nature (Sadler, 1989)
3. Visible; learning must be visible to the teacher and the student (Hattie & Yates, 2014)
4. Social; vocational learning does not occur in isolation from other people (Lucas & Spencer, 2015)

COGNITIVE APPRENTICESHIP

This approach was derived from a concern that learning is too often hidden (hidden leaning cannot be assessed, recognised, reinforced or valued by student or teacher). Collins et al. (1989) offered a six step visible learning process:

1. Modelling
2. Coaching
3. Scaffolding
4. Articulation
5. Reflection
6. Exploration

The process being learned must be actively taught by an expert (using the steps above), and the student should then undertake tasks that utilise the learned process in the context of their work.

FORMATIVE ASSESSMENT

Sadler (1989) wrote:

"Formative assessment is concerned with how judgements of the quality of student responses (performances, pieces or works) can be used to shape and improve the student's competence by short circuiting the randomness and inefficiency of trial-and-error learning."

"Formative" contrasts with "summative". Summative implies an "end of learning" summation for accreditation purposes. Formative assessment on the other hand is an integral part of the learning process. Summative assessment aligns with "marking or grading", whereas formative assessment is analogous to a system control feedback loop. Feedback in an apprenticeship situation is provided firstly by the employer (or a suitably qualified employee), and by students themselves through reflection.

Formative assessment is a natural part of the traditional apprenticeship model, but it should not be assumed that every employer will have the natural skills to provide such critical feedback. This aspect of the signature engineering apprenticeship pedagogy has significant implications for the structure and design of learning programmes – implications that we will return to.

VISIBLE LEARNING

The concept of visible learning was explicitly mentioned by Collins et al. (1989), but has since become increasingly recognised over a broad range of educational environments through the work of John Hattie, most significantly in other New Zealand educational sectors such as primary education. Lucas and Spencer (2015) list four key elements of Hattie's approach:

- The learning arising from any specific learning experience is given specific attention in the moment.
- Learners have specific, challenging, practical goals in mind and learning tasks are constructed with those goals in mind so that they are of benefit.
- Feedback is clear and plentiful. Learners recognise the need to welcome and listen to feedback.
- Teachers recognise learners' self-concepts and are fully able to coach them and to develop improved learning dispositions and strategies.

SOCIAL LEARNING

An engineer is expected to operate in a community – a social environment. The apprenticeship model is recognised as being a social learning experience. The apprentice learns alongside experts and other employees, possibly other apprentices. An apprentice is learning to belong to a community of practice. Lucas and Spencer (2015) consider the opportunity to pass on knowledge (the apprentice as teacher) to be an important feature of learning.

Lucas and Spencer (2014) also identify tried and tested learning methods such as those which involve:

- learning from experts
- deliberate practising
- hands-on learning
- feedback which promotes learning
- real-world problem solving
- one-to-one coaching and mentoring
- competing against the clock
- thinking critically and producing knowledge
- reflecting
- seamlessly blending of online and face-to-face learning

Lucas and Spencer (2014) also urge the UK government to put learning at the centre of the new apprenticeship reform and support employers, education and training providers to access well-researched and useful guides to best practice teaching and learning methods.

Conclusion

Apprenticeships are seen as a viable learning model for educating engineers. Major economies in the English speaking world have recognised this opportunity and actively promote experience-led learning through innovative apprenticeship models.

Our examination of experience-led learning literature shows that the apprenticeship model, while not being the only effective mode of learning, remains valid. The apprenticeship model emulates best practice in educational learning.

Furthermore, if the Government wishes to have a more diverse group of people engaged in the engineering profession, then apprenticeship programmes offer a learning model that has the potential to meet the needs of a wider range of learners than traditional classroom models.

This form of integrated vocational and knowledge-based education provides new pathways for students who have excelled academically at school, yet this model can potentially engage less academically successful students, leading to higher levels of skill acquisition than they might have otherwise attained. Diversity extends to disadvantaged groups in the community, potentially offering means for a wider range of people to join in the challenge to grow New Zealand's economy.

Chapter 5 English Models of Apprenticeships

The popularity of apprenticeships is resurging in many countries. It is opportune that England is currently going through one of the largest reforms to apprenticeships in decades. The UK government, employer-led Sector Skills Councils, education trusts (such as the Sutton Trust), City & Guilds Alliance for Vocational Education[4] have commissioned extensive reviews to support this reform (FISSS, 2013; Lucas & Spencer, 2015; Nash & Jones, 2013; Richard, 2012). These reviews are an important source of intelligence on how apprenticeships should be designed and implemented at a national level. Many of these reviews have considered models from other countries, such as Austria, Australia, Canada, Germany, Ireland, Switzerland and the United States, to inform their recommendations. In this report, we have included recommendations which we regard as pertinent to NZ.

This chapter focuses on the new initiatives in the English apprenticeship system, particularly at the higher levels of skills development. We have focused on the UK initiatives in preference to re-visiting models that were thoroughly reviewed by the UK researchers.

Trailblazers - A reform for change

The UK has reviewed the apprenticeship system in England, as many issues needed to be addressed. Nash and Jones (2013) succinctly outlines the problems and why there is a need for change:

- The education system is failing nearly half its young people by providing inadequate vocational opportunities.
- The UK labour market faces a fundamental skills mismatch, particularly training too few technicians.
- With 18,000 qualifications and around 150 awarding bodies, the system is too complex - creating confusion and bewilderment among students, parents and employers.
- Sector Skills Councils remain vastly under-resourced – they have one-tenth the funds of their German counterparts even though they have 18,000 qualifications to oversee, compared to 350 in Germany.
- Current funding incentives push students onto the academic A-level path (equivalent to NCEA level 3); too much low-quality vocational education is being taught in schools.
- Apprenticeships are of low quality and are too short compared to other leading economies.
- Too few employers offer apprenticeships (20% in the UK compared with 50-60% in Germany and Switzerland).
- Sector Skills Councils need more effective employer involvement and control with no more than five “preferred” qualifications for each occupation.
- 64% of UK apprenticeships are deemed to be of ‘low quality’
- Switzerland offers seven times as many high quality apprenticeships for its population size.
- 36% of UK apprenticeships are 3 years at Level 3 or higher - compares poorly with Germany where it’s 90%.

The report mandates for government wage subsidies and pooling schemes to help small businesses and information campaigns for employers and students on the cost benefits of apprenticeships.

The review conducted by Richard in 2012 called for 1) outcomes-based qualifications which link to standards for professional registration 2)employers and professional bodies to specify the ‘best’ qualification linked to an occupation 3) assessment to be independent with minimal interference from the Government 4)processes obtaining the outcome of the qualification to encourage innovation 5)purchasing power for apprenticeship training to lie with the employer. This has led to a major reform which fundamentally changes the relationship between employers, the government and those who educate and train apprentices.

In October 2013 the UK government published an implementation plan for delivering this apprenticeship reform in England(HMGovernment, 2013b). The method

[4] those who have a vested interest in ensuring apprenticeship systems are world class

uses 'Trailblazers projects', which is a pilot scheme operating over 2014/2015 and 2015/2016. Trailblazers are groups of employers and professional bodies that wish to specify an apprenticeship for a particular sector. The first pilot Trailblazer projects are outlined in Table 1. This first phase focuses on areas at the forefront of the UK economy and where professional standards are well established.

The pertinent point of this reform is that the UK government has focused on putting employers in the driver's seat; i.e. the employers lead these Trailblazer projects. The aim of these projects is to create a range of new apprenticeship standards and assessment approaches in different sectors and occupations. The government has stated that it is essential that the standards developed work for both larger and smaller businesses; especially as the government wishes to encourage more small and medium-sized business to take on apprentices. Professional bodies are also part of defining and shaping these apprenticeships, to ensure that an individual is ready to secure professional accreditation where available. "Apprenticeships will be based on standards designed by employers to meet their needs, and apprentices will need to demonstrate their competence through rigorous, independent assessment designed with employers" (HMGovernment, 2013b).

Employers and professional bodies generate apprenticeship standards and assessment approaches. The education and training providers are the 'suppliers' to meet the standard and are typically not party to specifying the standards. However, whilst the government has not stipulated that education providers are part of each Trailblazer project, the UK government encourage Trailblazers to involve educationalists in discussions so that they are geared up and ready to deliver against the new standards.

Table 1: Initial Trailblazer Projects (HMGovernment, 2013a)

SECTOR	OCCUPATION	EMPLOYERS	PROFESSIONAL/INDUSTRY BODY/EDUCATION PROVIDER
Aerospace	Aerospace Manufacturing Fitter	Airbus, BAE Systems, GKN Aerospace, Magellan Aerospace UK Ltd, Marshall Aerospace and Defence Group, MSM Aerospace Fabricators, Rolls-Royce	Institution of Engineering and Technology The Royal Aeronautical Society
Automotive	Automotive Mechatronics Maintenance Fitter	Bentley Motors, BMW Group UK, Ford, Jaguar Land Rover, Siemens, Toyota, Vauxhall Motors	Institution of Mechanical Engineering Manufacturing UK EEF – Private Training Provider
Digital Industries	Software Development and Networking	Accenture, BT, BCS, CapGemini, Cisco, IBM, Microsoft,	Chartered Institute for IT Test Factory – Private Assessment Service Provider
Electrotechnical	Installation Electrician and Maintenance Electrician	Balfour Beatty, Barlows Electrical, Daly Limited, Darke & Taylor Ltd, National Grid, UPM Shotton Paper	Institution of Engineering and Technology Joint Industry Board for the Electrical Contracting Industry
Energy and Utilities	Maintenance Engineers	British Gas, the Clancy Group, E.ON, Leven Energy Services, National Grid, Northumbrian Water, Thames Water, Viridor	Institution of Engineering and Technology Institution of Gas Engineers and Managers
Financial Services	Corporate Banking, Digital Marketing, Compliance and IFA Network Administration	Barclays, Capita, HSBC, Lloyds, Santander, Sesame, Openwork	
Food and Drink Manufacturing	Food and Drink Maintenance Engineer	Arla Foods (UK), Dairy Crest, First Milk, Fosters Bakery, Haribo, McCain Foods (GB) Ltd, MondelĐz International, Mūller Dairy, Nestlé UK, Premier Foods, Thorntons PLC, Unilever UK	Institution of Engineering and Technology Institution of Mechanical Engineering
Life Sciences & Industrial Sciences	Laboratory Technician, Science Manufacturing Technician and Medical Technology Technician	Fujifilm Diosynth, GSK, Johnson & Johnson, Lotte Chemical UK Ltd, Lucite International, MedImmune, P3 Medical Ltd, Seralab, Synergy Outsourcing, Victrex Plc	Institute of Chemical Engineering Royal Society of Chemistry Society of Biology

The Lord Sainsbury's Gatsby Foundation has agreed to partner the government in supporting the first phase of

Trailblazers. Up to £1.6 million of funding was made available in 2013/2014 to support the projects. This funding supports the Trailblazers throughout the entire process of the development of each standard and assessment approaches. The funding contributes towards the costs of developing the new apprenticeships and supports activities such as: research on employment outlook, labour market analysis, professional standards development, etc.; consultation with the wider sector; coordination of meetings; financial support for small business to meet expenses related to the Trailblazer project.

OUTCOMES FOCUS - SETTING STANDARDS AND ASSESSMENT APPROACHES

Each Trailblazer has been provided with guidelines to help specify how an apprentice should demonstrate mastery of an occupation, i.e. a standard. Each standard will be short, easy to understand and describe three core components for an apprentice to be able to undertake a specific occupation:

1. Skill
2. Knowledge
3. Competency/Behaviour

The apprentice will be assessed against this standard. Just as there will be a single apprenticeship standard for a given occupation, there will also be a single approach to assessment against that standard. Independence of assessment is important and there is an expectation that assessment will be delivered by an independent third party to ensure that the employer is confident that apprentices assessed in different parts of the country at different times all have the same standard. The requirements are 1) apprentices will be assessed largely at the end of their contract with an expectation that at least two thirds of the assessment must take place towards completion 2) there will be a synoptic element to the end-point assessment, requiring the apprentice to identify and use effectively a selection of skills, techniques, concepts, theories, and knowledge from across their training. The introduction of largely end-point assessment shifts the focus of apprenticeships to the outcome: what an apprentice knows and is able to do at the end of his/her programme. This enables certification of full competency against the standard.

Each standard will meet professional registration requirements where these exist (e.g. engineering).

UK Engineering Qualifications and Professional International Equivalence

In the UK a bachelor's degree is at level 6 and a master's degree is at level 7 on the Qualifications and Credit Framework (QCF). These are (in the NZ engineering context) the equivalent qualifications on the New Zealand Qualification Framework (NZQF) to a Bachelor of Engineering Technology (BEngTech level 7) and a Bachelor of Engineering with Honours (BEHons level 8).

However, there is quite a complex system in place with regards to professional registration in the UK. A MEng(Hons) degree in engineering is the qualification required to become a Chartered Engineer (CEng), under the UK Standard for Professional Engineering Competence (UK-SPEC), i.e. a qualification meets the Washington Accord. However a MSc (where a student may have a bachelor degree in another subject area) is deemed to partially meet the requirements to become a Chartered Engineer, i.e. termed Partial Chartered Engineer (Further Learning) [CEng (FL)] and therefore a programme of accredited further learning is required to complete the educational base for CEng. The Bachelor with Honours (BEng(Hons)) degree in engineering is also deemed to partially meet the requirements to become a Chartered Engineer, i.e. [CEng (FL)]. Whereas the BSc(Hons) degree, which is usually related to niche offerings (e.g. motorsports technology, sound engineering and production, technology management, interactive media development, computer networking, aerospace technology with pilot studies, automotive technology with management, mechanical and vehicle technology) is the qualification required to become an Incorporated Engineer (IEng), i.e. meets the Sydney Accord.

The government provided the Trailblazers with guidelines for setting out the new standards (HMGovernment, 2013a). "The assessment will cover the *whole* standard and will therefore need to test both theoretical and practical elements of the apprenticeship.

This will require mixed methods of assessment, which may include:

- Written and multiple choice tests;
- Observational elements;
- Practical synoptic assessments;
- A examination to assess theoretical or technical knowledge or discuss how the apprentice approached the practical assessment and their reasoning;
- Production of a project, or a portfolio of work; and
- Virtual assessment, such as online tests or video evidence as appropriate to the content"

There is also a mandatory minimum amount of time that has been specified for an apprentice to spend in off-the-job training, which is a minimum of 20% or equivalent. Also, the government wish that new apprenticeships utilise the latest technology in their design and delivery through further use of e-learning/ assessment.

Once a Trailblazer project has specified a standard and assessment approach they must submit this 'draft' to their relationship manager at the Department for Business, Innovation & Skills. A panel involving employers and academic representatives, as well as experts on assessment, is convened to provide advice on the draft standard and its agreed status.

Once the standard has been agreed the Trailblazer project is tasked to develop the detailed assessment system that supports the standard, including the design of any written and practical tests, the associated marking scheme and details of delivery. It is expected that education and training providers are involved in developing content for delivery.

Degree Apprenticeships

The review of apprenticeships has shifted its focus from mainly lower level apprenticeships (level 3 and below) to now include higher level apprenticeships.

> *"An apprenticeship is first and foremost a job with substantial training and the development of transferable skills. It is a way for people of all ages to earn while they learn, gaining a qualification and a real future. Apprentices will be aged 16 or over, must be in paid employment for the duration of their apprenticeship, and will combine working with studying for a work-based, academic or combined qualification. Typically, higher apprentices study part time at college, university or with a training provider, often sat alongside students studying full time for the same qualifications" (SFA, 2015).*

The degree apprenticeships, which are being launched in England during September 2015, will allow apprentices to achieve a full bachelor's or master's degree as a core component of the apprenticeship. Degree apprenticeships combine higher and vocational education and fully test both the wider occupational competence and academic learning, using a fully-integrated degree co-designed by employers and HEIs, or a degree plus separate end-test of professional competence.

The new degree apprenticeship model has a number of benefits for employers, prospective apprentices, and universities (HMGovernment, 2013a).

- Employers can attract high-calibre school-leavers who are keen to earn a full bachelor's or master's degree in a work-based environment. This will allow students to acquire the graduate/post-graduate level skills they need, while the training costs, including the degree, are co-funded by government.
- The apprentice will be employed, paid a wage and will gain a full degree (bachelor's or master's), as well as a head-start into their chosen profession
- Universities can strengthen links with local employers and offer degree programmes that better meet employer needs and are accredited by professional bodies, while also having a new product to offer prospective applicants

Table 2 shows the five degree apprenticeships currently available in England mainly serving the automotive and digital industries sectors (HMGovernment, 2015c). Additional degree apprenticeships are currently in development in several areas including electronic systems, nuclear and civil engineering and chartered surveying.

Table 2: Degree Apprenticeships Offered in England in 2015 (HMGovernment, 2015c)

SECTOR	OCCUPATION	QCF LEVEL
Automotive	Control/Technical Support Engineer	6
	Electrical/Electronic Technical Support Engineer	6
	Manufacturing Engineer	6
	Product Design and Development Engineer	
Digital Industries	Digital & Technology Solutions Professional	6

An important aspect of the degree apprenticeship scheme is government funding:

- Funding of these apprenticeships is shared by the government and the employer.
- Government will contribute £2 for every £1 cash contribution made by the employer up to the maximum government cap for each standard, which for engineering is £18,000[5]
- The employer will negotiate the cost of the training with the provider and or the assessment company. This may be less than the maximum government cap.
- An additional payment will be made by the government upon completion of the standard, typically £2,700.
- An additional payment will be made by the government to employers with less than 50 employees, typically £2,700.
- The salary provided to the apprentice is an additional cost and is typically between £10-15K p.a.

NOTE: There are no polytechnics in the UK.
The responsibility to deliver the equivalent of a NZQA level 7 Bachelor of Engineering Technology degree (i.e. a BEng(Hons) or BSc(Hons) degree in the UK) and above lies with the universities.

Due to the recent development of these types of apprenticeships, information about them is incomplete. The following case studies are based on an extensive literature and web-based search and are supported with an interview with a representative from a participating university to ensure that our synthesis of information is correct. We have only provided two viewpoints from the UK educational sector based on an interview with those who have had a direct involvement in the Trailblazer project. This small sample may not be representative.

CASE STUDY Manufacturing Engineering Degree Apprenticeship – Jaguar Land Rover and Warwick University

LITERATURE AND WEB-BASED SEARCH ANALYSIS

A specification for the apprenticeship standard and assessment plan for a manufacturing engineer has been developed (HMGovernment, 2015b). The Trailblazers[6] have specified an entry route focused on 18 year old school/further education college leavers that have met the following criteria: 5 GCSE's (equivalent to NCEA Level 1) and two A-Levels at grade C or above (equivalent to NCEA Level 3) including mathematics and science, technology or engineering based subjects. It typically takes 6 years to complete the apprenticeship.

The Trailblazers started small in the development and testing of this standard. They stated that they will use the experience of 'best practice' in apprentice development (i.e. Toyota and Jaguar Land Rover) to ensure that the standard and assessment regime is feasible and transferable. They are also extremely conscious that what is developed should be fully transferable to small companies and so are consulting widely across the automotive sector. They have also stipulated that these apprenticeship reforms do not lead to a two-tier system where only companies with the greatest influence and resources are able to benefit.

[5] government pays 2/3 of the apprentice's tuition fees (e.g. with a private training provider or university) with employers paying the remaining 1/3.
[6] Bentley Motors, BMW Group UK, Ford, Jaguar Land Rover, Siemens, Toyota, Vauxhall Motors, Institution of Mechanical Engineering, Manufacturing UK and

Figure 6 provides a sample of the standard's outcomes, specific skills and knowledge required of a Manufacturing Engineer. For a complete list of the standard's outcomes refer to (HMGovernment, 2015b).

MANUFACTURING ENGINEERING OUTCOMES

Vocational Skills

- Complying with statutory regulations and stringent organisational safety requirements
- Producing components using hand fitting, fabrication and joining techniques
- Producing Computer Aided Design (CAD) models (drawings) using a CAD system
- Preparing and using lathes, milling and other general or specialist machines and high tech equipment

Academic Knowledge

- Mathematics and science for engineers
- Materials and manufacture
- 3D Computer Aided Design and Computer Aided Engineering
- How to run and manage business led projects
- Engineering operations and business management

Occupational Behaviour

- Safety mind-set
- Strong work ethic
- Problem solving orientation

Figure 6: Sample of Outcomes for a Manufacturing Engineer (HMGovernment, 2015b)

There are two phases to the apprenticeship: Foundation and Development and at each phase there are two 'sign-off' assessments. Each phase develops the apprentice in vocational *skills*, academic *knowledge* and occupational *behaviours*; as specified in the standard. Figure 7 summarises how JLR have applied the standard, which has been based on our interpretation of information provided by JLR's website regarding apprenticeships (JLR, 2015a, 2015b) and Warwick University's website regarding their Bachelor of Engineering in Applied Engineering Programme (Warwick, 2015). What is interesting is the use of currently well regarded National Vocational Qualification Standards (NVQs) to develop the vocational skills and Foundation and Bachelor of Engineering degrees to cultivate the academic skills. All these qualifications are nationally recognised through accredited educational providers and are transferable to other career paths and to higher forms of qualifications, i.e. Master's degree (MEng or MSc).

With regards to the academic provision, both Foundation and Bachelor degrees are delivered in a flexible mode to suit students working in industry. To ensure the curriculum and delivery mode suits industry based students, all vocational qualifications (NVQs) have been reviewed by the Trailblazers and three main awarding bodies (i.e. City and Guilds, Pearson and EAL). The academic qualification [BEng Degree in Applied Engineering (Warwick, 2015)] has been reviewed by a number of companies, including Jaguar Land Rover, Rolls-Royce and Network Rail.

FOUNDATION PHASE INTENSIVE 'OFF-THE-JOB' TRAINING	FOUNDATION PHASE END TEST	**DEVELOPMENT PHASE** GREATER DEGREE OF 'ON-JOB' TRAINING	EMPLOYER ENDORSEMENT PHASE
Skills: Assessed by observation and portfolio & mandatory NVQ units. Minimum 1400 Guided Learning Hours (GLH). E.g. NVQ2 Performing Engineering Operations (340 GLH) NVQ3 Business Improvement Techniques (433 GLH) Plus other NVQ options	Synoptic Assessment that allows student to integrate their skills, knowledge and behaviour. In-house 3 day scenario based competency assessment. Summative external assessment through practical & behavioural tests.	**Skills:** Assessed by observation and portfolio & mandatory NVQ units. NVQ4 Engineering Manufacture (844 GLH) Plus other NVQ options	Synoptic Assessment that allows student to integrate their skills, knowledge and behaviour. An end-point interview with company and an independent assessor
Completed 'off-the-job' by Private Training Providers 37 weeks - typical spread over 2 years		Completed 'off-the-job' by Private Training Providers	
Knowledge: Foundation Degree		**Knowledge:** BEng Degree in Applied Engineering at Warwick University	
Completed 'off-the-job' by Further Education Colleges 40 weeks – typical spread over 2 years with up to 2.5 day release to attend college		Completed 'on & off the job' at Warwick University over 4 years. 6 modules per year. Each module runs as a 'block release' over 5 days at the University. Access to a 'virtual learning environment' where students can embed their learning in the workplace.	
Behaviours: No formal qualification –based on min. 3 reviews		**Behaviours:** No formal qualification –based on min. 3 reviews	

Figure 7: Jaguar Land Rover Application of the Manufacturing Engineering Apprenticeship

There are 2 'sign-off' points by the employer, i.e. Foundation Phase End Test and the Employer Endorsement Phase. These are formal assessment points where an apprentice is expected to demonstrate his/her competence in all three attributes: skills, knowledge and behaviour. The employers are expecting that just by doing a job and passing qualifications is not enough to prove competency. They are expecting the integration of these capabilities to be evidenced at the end of each phase of the apprenticeship.

The apprentice at the end of the development phase will be recognised by appropriate engineering accrediting body. The Institution of Mechanical Engineering has indicated that the manufacturing engineer apprentice will initially obtain Engineer Technician registration (i.e. Dublin Accord) with post apprenticeship development to obtain Incorporated Engineer registration (i.e. Sydney Accord).

INTERVIEW ANALYSIS - DIRECTOR OF UNDERGRADUATE PROGRAMMES, WARWICK UNIVERSITY (WARWICK)

This interview represents the perspective of the Director of Undergraduate Programmes at Warwick University, involved in the Trailblazer Project. The interviewee's views may not be representative of the University. This section summarises pertinent points from the interview. The interviewee's perspective provides valuable insights, adding detail and depth to our understanding of the early stages of the Trailblazer journey.

Trailblazer Process – Generating the Apprentice Standard

Whilst Jaguar Land Rover (JLR) is part of the Trailblazer project, their association with Warwick's Bachelor of Engineering in Applied Engineering Programme (AEP) originated prior to the government's launch of the degree apprenticeships. The AEP was generated in response to JLR's needs to upskill its current workforce, particularly long-serving staff. The resultant degree was termed as a 'sponsored degree' by JLR and launched in September 2013.

Immediately after launch of the sponsored degree, Warwick was approached to consider whether the AEP would be able to meet the needs of the manufacturing engineering degree apprenticeship. It was deemed the AEP was appropriate and the first apprentices began in September 2014.

This was ahead of other Trailblazer projects as the degree was already being delivered to the satisfaction of industry; albeit one major employer in the automotive sector. For JLR, it was a win-win situation to be part of the Trailblazer project and have Warwick AEP accredited under the apprenticeship scheme. They now have 2/3rd of training and education fees paid for by the government. This resulted in the number of sponsored students declining and the number of apprentices increasing.

With regards to the manufacturing engineering trailblazer project, it appears that there has not been much collaboration between the automotive industry and tertiary providers. In this case, as JLR and Warwick already had a working model, this became part of the project, rather than developing a new education programme from scratch. When asked about how other automotive companies and universities are implementing the apprenticeship standard, the response was that not much has been done. However, it was acknowledged that the government's roll-out of this has been extremely quick. The limited time for implementation may have hindered those universities, who lack experience of educating part-time (work-based) students, from becoming part of the Trailblazer project.

Employers' Perspectives

Note that this example is largely focussed on the requirement of one company, i.e. JLR.

JLR's manufacturing plants are dispersed across the UK. This influenced the delivery model of the degree, which resulted in a block mode of 5 days enabling employees to attend university.

Each 5 day block consists of 30 hours of teaching (08:30 to 16:45). Taught sessions last 50 minutes, with a 10 minute break between, and there is a 45 minute lunch break. There are 7 blocks per year. The academic year runs from September to July, which is approximately 3 months longer than the full-time cohort, due to the automotive industry's 'shut down' schedule. The delivery mode has been designed to specifically suit JLR's requirements.

When questioned about how funding has incentivised employers to engage with universities, the interviewee replied:

> *"Funding...that certainly seems to be working"*

The interviewer explored how other companies, particularly very small companies, would view Warwick's degree apprenticeship delivery model. Warwick's intention has always been to widen the AEP to other companies. There are six companies currently involved in the first year cohort, mainly other large organisations, such as Network Rail. Warwick tries to accommodate other companies and (at times) other sector's requirements by providing tailored examples in their teaching and customising assessments.

The interviewee acknowledged that with regards to delivery models SMEs tend to prefer day release, rather than block release. If there was a push for this type of delivery, then Warwick would have to significantly change their delivery model, as stated: "have to throw the baby out with the bath water." Another concern was how difficult it was to meet the distinct needs of different employers:

> *"Getting companies involved right at the outset is crucial. You do have to be careful as every company wants a bespoke programme just for them and then when you drill down to how many people are actually going to attend the programme (they may say) ooh two or three if you're lucky…so you're not going to be putting on a bespoke programme just for those."*

The Trailblazer project requires that the apprentice reform does not lead to a two-tier system where only companies with the greatest influence and resources are able to benefit. Reflecting (on the discussion) the interviewer acknowledges that Warwick and JLR are ahead of the game and doing some great work. However the interviewer is not convinced that other automotive companies (particularly SMEs) are engaged with other educational institutes to implement the manufacturing engineer degree apprentice standard in their organisations. It will be interesting to see how the automotive manufacturing engineering Trailblazer project progresses to ensure that a wide range of companies are included and does not unintentionally result in a two-tier system.

Warwick's Perspective

The AEP is a success, mainly due to the close association with JLR. Student numbers are growing: 1st intake 39 students; 2nd intake 77 students; 3rd intake 90 students; 4th intake 120 projected students.

Whilst Warwick sees growth in this area, the interviewee believes a significant issue of these degree apprentices programmes is that universities do not actively engage with companies. For example, the interviewee attended a national event in London concerning degree apprenticeships where most Further Education Colleges and Post-1992 universities were represented but only three Pre-1992 attended.

> *"A lot of the older universities don't seem to have woken up to the fact that there is an extremely big market out there"*

Trailblazer apprenticeships seek to attract A level students (school leavers) and Warwick University has no issue convincing prospective students who seem very aware that "it's a way of not accumulating £40K of student debt". Whilst Warwick University typically attracts full-time A level school leavers there does seem to be an increase of interest from these students to attend university as an apprentice studying part-time:

> *"recently we held a University Open Day aimed at prospective students for October 2016. Quite a number were asking about Degree Apprenticeships and the AEP as part of that"*

However, the challenge remains with parent's perception that apprenticeships are associated with lower levels of qualifications. Parents therefore need to be assured that the degree is the same standard as the fulltime degree.

There is a negative perception held by the sponsored/apprentice students in how they compare themselves with fulltime students:

> *"They often feel as though they are not as good as the fulltime student… I teach both (full and part time) and … I would put the part timers up against the full timers any day of the week"*

The interviewee believes that this viewpoint occurs when students focus on the fact that they perceive they do not learn theoretical engineering concepts. However, the point is made that theory is only useful if applied in the right way. Companies are used to training, not educating and the interviewee finds it a struggle to get students thinking that they're not just training:

> *"Training teaches you how to solve problems that people have already solved, education teaches you how to solve problems that people haven't yet solved… giving you innovation, competitive edge..."*

This is an important issue regarding the perception of how students, parents, employers, etc. perceive apprenticeships.

What was also clarified in the interview is that Warwick University will be seeking accreditation of the AEP to ensure graduates are able to obtain Incorporated Engineer registration (i.e. Sydney Accord) and are also exploring the development of a masters programme that will allow stair casing to higher degrees and routes for Professional Engineer registration (i.e. Washington Accord).

CASE STUDY Digital and Technology Solutions Professional Degree Apprenticeship

LITERATURE AND WEB-BASED SEARCH ANALYSIS

A specification for the apprenticeship standard and assessment plan for a Digital & Technology Solutions Professional has been developed (HMGovernment, 2015a). The Trailblazers[7] partners have specified a single entry route to the apprenticeship. It is focused at 18 year old school leavers with A-Levels or a BTEC level 3 (equivalent to NCEA Level 3). It would typically take up to 4 years to complete the apprenticeship.

The Digital & Technology Solutions Professional apprenticeship standard has a set of core outcomes (i.e. skills, knowledge and behaviours), which are supplemented by one of six specialisms:

- Software Engineer
- IT Consultant
- Business Analyst
- Cyber Security Analyst
- Data Analyst
- Network Engineer

Figure 8 provides a sample of the standard's core outcomes, specific skills, and knowledge required of a Software Engineer. Please refer to (HMGovernment, 2015a) for a complete list of the standard's outcomes.

DIGITAL & TECHNOLOGY SOLUTIONS PROFESSIONAL CORE OUTCOMES	SOFTWARE ENGINEER SPECIALISM OUTCOMES
Core Skills Information Systems: is able to critically analyse a business domain in order to identify the role of information systems, highlight issues and identify opportunities for improvement through evaluating information systems in relation to their intended purpose and effectiveness. **Core Knowledge** • How business exploits technology solutions for competitive advantage. • The value of technology investments and how to formulate a business case for a new technology solution, including estimation of both costs and benefits. **Core Behaviour** • Fluent in written communications and able to articulate complex issues. • Makes concise, engaging and well-structured verbal presentations, arguments and explanations.	**Specialism Skills** • Create effective and secure software solutions using contemporary software development languages to deliver the full range of functional and non-functional requirements using relevant development methodologies. • Undertake analysis and design to create artefacts, such as use cases to produce robust software designs. • Produce high quality code with sound syntax in at least one language following best practices and standards. **Specialism Knowledge** • How to operate at all stages of the software development lifecycle. • How teams work effectively to develop software solutions embracing agile and other development approaches. • How to apply software analysis and design approaches.

Figure 8: Sample of Core and Specialism Outcomes for a Digital & Technology Solutions Professional

A defining feature of this Trailblazer project is that the group of employers have worked closely with universities to ensure that the outcomes (in skills, knowledge and behaviour – specified in the apprentice standard) are demonstrated at completion. Therefore, it is the achievement of the degree that ensures the standard has been met.

Completion leads to the award of a Bachelor of Science with Honours [BSc (Hons)] in Digital & Technology Solutions, a qualification that is nationally recognised through accredited educational providers and is transferable to other career paths and to higher forms of qualifications, i.e. Master's degree.

Seven universities have been involved in developing this degree[8]. The degree is a 'closed degree' because only students that are apprentices employed at companies may enrol.

[7] Accenture, BT, BCS, CapGemini, Cisco, IBM, Microsoft, Chartered Institute for IT and the Test Factory.

[8] Aston University, University of Exeter, University of Greenwich, Loughborough University, Manchester Metropolitan University, University West England and University of Winchester.

There is some flexibility in how each university develops the programme, but it is essential that each university can map how each module (i.e. paper in a NZ context) contributes to the development of an outcome specified in the apprentice standard. Figure 9 provides an overview of the assessment of the standard's outcomes. There are two main forms of assessment:

1. Formative Assessment – This allows the university and employer to monitor student learning and provide ongoing feedback that helps students identify their strengths and weaknesses and target areas that need work. It also helps faculty and employers to support the apprentice and provide extra guidance where performance issues might arise. Whilst this method is widely used in academic circles it is usually associated with assessments that have no credit value. However, in this context the term formative is used to represent 'constant feedback' and it is expected that assessments taken in university modules are examined in accordance with university regulations, i.e. utilises a wide selection of appropriate assessment methods (test, report, exam, presentation, etc.) that are graded and externally moderated through the appointment of an external examiner.
2. Final Synoptic Assessment – This is a substantial piece of work that typically takes 6 months to complete alongside the apprentice's normal duties to their employer. This assessment involves completion of a project and presentation that must be able to test the skills, knowledge and behaviour specified in the standard.

The final synoptic assessment is a partnership 'sign-off', with the employer and university assessing the apprentice at the end of the degree.

The apprentice standard clearly stipulates the roles of the apprentice, employer, university and external examiner in relation to the assessment. For example, as outlined by Manchester Metropolitan University (MMU, 2015b), the employer has certain obligations to fulfil to ensure that assessments are tailored to the work that the apprentice is involved in. This requires:

- Providing a mentor who will oversee the work and development of the student and who can coordinate projects and learning with the university tutor
- Providing a varied work programme which allows apprentices to turn theory into practice, develop skills relevant to the organisation, and achieve outputs with real business value
- Permitting evidence of commercial value to be included in assessments
- Attending any presentations and completing an assessment of the final project report using defined assessment criteria

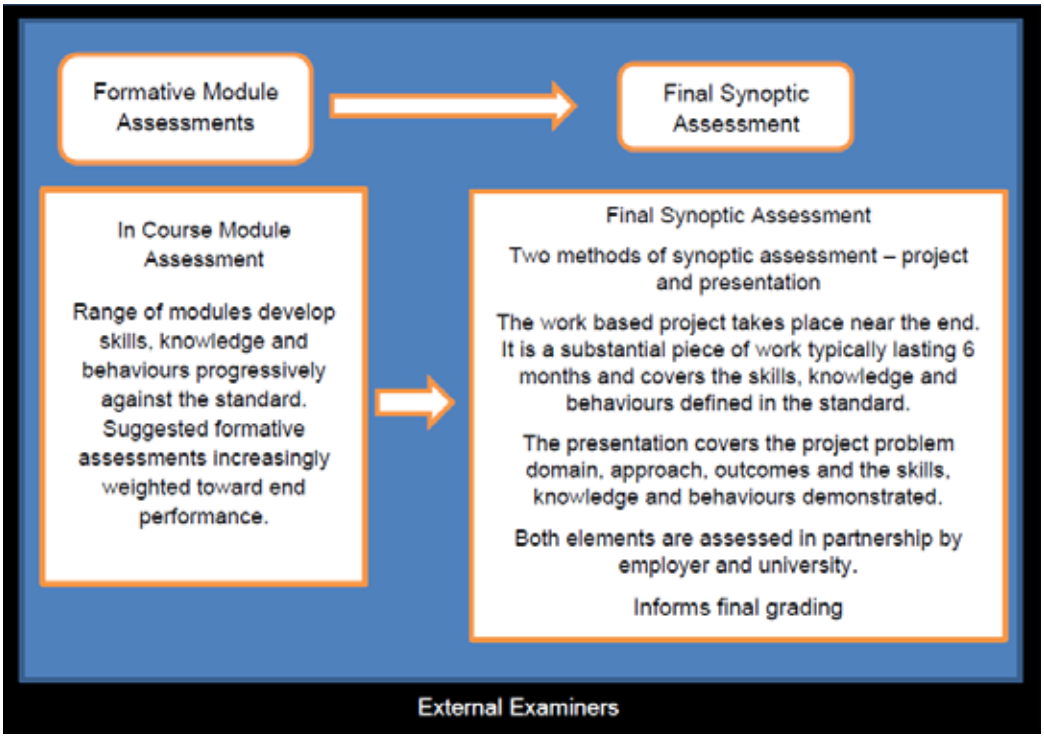

Figure 9: Overview of assessment for a Digital & Technology Solutions Professional (HM Government, 2015a)

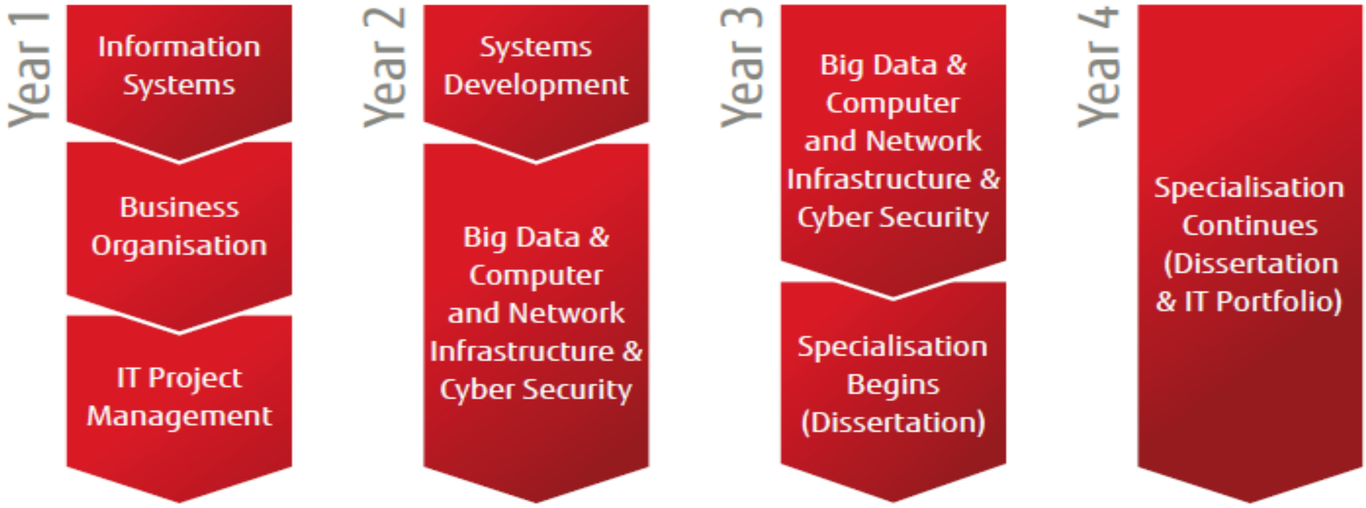

Figure 10: Typical BSc (Hons) in Digital & Technology Solutions Degree Structure (Fujitsu, 2015)

Due to limited information currently available (as universities are currently developing the degree) Fujitsu has provided a summary of how the degree is structured in Figure 10.

At the time of writing this report, the authors found three universities that are currently marketing the BSc (Hons) in Digital & Technology Solutions (Aston University, Manchester Metropolitan University, and University of Winchester). Each university provides the degree programme outlined by Fujitsu using specific delivery modes, described in Table 3.

Table 3: Delivery Modes (Aston, 2015; MMU, 2015a; Winchester, 2015)

Aston University	Programmes will be delivered through blended learning: most teaching will be delivered as 'learning objects' (typically recorded lectures, case studies, talks etc.) through a virtual learning environment which can be accessed at the student's convenience. At the start of the programme, a three-month accelerated learning block held on campus will deliver the core computing and business skills needed to enable the apprentices to become a useful member of a team for their employer. There are a four on-campus two-day blocks per year in order to run group activities. Online tutorials typically take place out of office hours through on-line video conferencing delivering teaching to students who are working on client site, have irregular working patterns, and are dispersed across the country (and, potentially, in different time zones).
Manchester Metropolitan University	The degree is a part-time course run over four years using a mixture of day release and blocked teaching which is equivalent to approximately 3 days per month.
University of Winchester	Programme is delivered partly through taught sessions at the University and partly through employer supported work-based learning

INTERVIEW ANALYSIS - PROGRAMME DIRECTOR, MANCHESTER METROPOLITAN UNIVERSITY (MMU)

This interview represents the perspective of the Programme Director of the BSc (Hons) in Digital & Technology Solutions, involved in the Trailblazer Project. The interviewee's views may not be representative of the University. This section summarises pertinent points from the interview. The interviewee's perspective provides valuable insights, adding detail and depth to our understanding of the early stages of the Trailblazer journey.

Trailblazer Process – Generating the Apprentice Standard

A key player in the process is the Tech Partnership. The Tech Partnership represents a network of employers who wish to create skills to accelerate the growth of the digital economy. The Tech Partnership is recognised by the UK government as the *Industrial Partnership for the Information Economy*. They provided two facilitators to operate the Trailblazer project, one chaired the sessions and the other developed the apprenticeship standard. The chair is highly influential in the process and seems to have extremely good links with industry. The standard has been developed very quickly and probably wouldn't have been achieved in the time without the excellent facilitation of the Tech Partnership.

The process began in early November 2014 and consisted of employers and representatives from six universities generating the standard and assessment. The meetings were held every 2 weeks by teleconference; although they were more frequent (each week) if required. Each meeting typically consisted of 30 to 40 members and lasted 2.5 hours.

The Tech Partnership facilitator provided updates of the standard as it was being developed so that the Trailblazer team could comment and make additions, etc. They are continuing to have meetings, albeit less frequently.

The generation of the standard involved a collaborative approach between employers and educators. There were times when employers and educators disagreed (e.g. the title of the degree) and the interviewee explained that it was usually the employers who had the last say:

> *"… which (at times) put the backs up some of the universities"*

That said a strong and respected chairperson is crucial to ensure that all parties' views are considered and that the process was kept on track. It is apparent that the resulting standard was created in a collaborative manner and that all parties are happy with the result and the process.

What is pertinent about this Trailblazer project is that the committee managed to set the standard for a multitude of jobs in the sector rather than just one. This is quite different to other Trailblazers, who seem to be specifying standards for a single occupation. For instance, the Trailblazers spent a lot of time discussing the core outcomes of the apprentice who will work in the digital and technology arena but then, taking an innovative approach, agreed certain outcomes for various specialisms (software engineer, IT consultant).

The Tech Partnership has been instrumental in ensuring that the degree apprenticeship is developed. There was a discussion about who's paying the Tech Partnership for taking the lead in getting the standard accredited, a point that employers are currently disputing. This is an important point as it seems that facilitation of these Trailblazers is crucial but who is going to pay?

Employers' Perspectives

MMU's employer base is extremely varied, from very large companies (BBC, Bentley and Network Rail) to very small (< 20 employees). MMU has a strong connection with businesses that has been built through their Centre for Enterprise. For instance, they operate the Goldman Sachs 10,000 Small Business programme, where MMU staff work with businesses typically employing between 5 and 100 employees. They have also a European funded project 'Knowledge Action Network' that helps SMEs address their business challenges.

MMU promoted the apprenticeship through this extensive network of employers. They launched the degree in January 2015 with 60 employers attending.

The interest from employers seems buoyant. In fact the interviewee's comment about how the new apprenticeships were received by employers across the UK, sums up the amount of interest it's developed:

> *"….not totally convinced that BIS (Department for Business, Innovation & Skills) knew what they were taking on…… thousands of employers have got involved…..BIS inundated with positive response from employers"*

The government's aim of putting employers in the driving seat has certainly generated interest.

The employers also seem happy with what's happening. For instance one of MMU's collaborators (Bentley) stated that:

> *"he knows exactly what they're (the apprentice/graduate) coming with (to work with us)"*

However, small businesses (<20 employees) are interested but are reticent to take on an apprentice until they see it up and running. The employers who are joining now are tending to be the larger businesses who already take on apprentices. That said, some of the large employers (BBC, Bentley, Lloyds and Network Rail) are delaying implementation, either to ensure that they have the appropriate recruitment systems in place or are in existing apprentice contracts that require changes.

Employers (20-30 employees) are keen. App developers, who are in rapid growth and keen to get young talent, are joining up to work more closely with the university.

There are expectations that employers must provide a salary, a flexible work schedule and a mentor. Many companies that MMU deal with already employ apprentices so there are systems in place to deal with these expectations. For example, AstraZeneca, Barclays and Lloyds support the apprenticeship scheme and have employees who are competing to enrol in the degree programme.

For this degree the employers are expected to send their apprentice to attend MMU. The question of whether block courses are preferable to day release as delivery models was discussed and surveyed; resulting in employers split 50:50.

The result is that an apprentice has to spend 1 day per week over 2 semesters (24 weeks) at MMU, mixed in with block courses of 1 week, depending on the subject being taught. For example, programming is to be taught over 1 week as it's deemed the best way to teach, whereas another module will be taught in 1 day blocks over the semester. The total amount of time spent at MMU is 36 days per year.

MMU avoids companies who only pay minimum wage. They believe if a company is paying the minimum, they are probably not fully committed and more likely to get rid of the apprentice, which is a risk to MMU as they too would lose the student. MMU advises companies to pay at least £12K and promotes the mantra "it's not about getting cheap labour it's about developing your staff."

MMU are currently developing a contract with the employers and are just waiting for the government to confirm funding before finalising it.

Government funding goes to MMU at the moment (over the next 2 years). The employer pays the university 1/3 of the fees. As soon as the company has paid the university, the university claims 2/3 from the government. Note the employer pays £9K over 4 years and government pays £18K over 4 years

The proposal by the government of employers to receive funding directly will be operational after the pilot stage (in a couple of years).

MMU's Perspective

On the whole MMU are very happy with their involvement. The chance to directly link with employers is the driver. Due to their past experience with delivering higher apprenticeships (in chemical science and law) and working closely with industry they were approached to be part of the Trailblazer project.

As it is a 'closed degree' for apprentices only, MMU does not see it competing with other degrees (i.e. software engineering, digital marketing) because it is a completely different model.

The potential student numbers are buoyant with at least 40 apprentices signed up already, although these are mainly from AstraZeneca, Barclays Bank and Lloyds. MMU believe the funding is sufficient, and allows the potential to buy-in staff to cope with the demand.

Whilst many recruits are currently apprentices wishing to upskill, the main applicant type is the school leaver with A levels. MMU are actively marketing the degree and have conducted open evenings where employers meet potential apprentices. The team leading the apprentice degree feel that they are 'swimming against the tide' with the rest of the university in terms of recruitment systems and processes. Apprenticeships are currently not the university's main business and so the central systems are not yet geared up to deal with this kind of applicant. However, MMU are working hard to integrate this new venture in central university systems with active support from some very senior managers.

It is expected that the apprentice will spend time studying at MMU (i.e. 1 day per week or 1 week in a block) with study time (reading and assessment) to be carried out at the company or in a student's own time. A unit leader coordinates the assessment with each apprentice and their company. Typically, the assessment is in the form of a project that is completed at the company. This is negotiated between the company and MMU, with the student acting as a link. A concern raised by the interviewer was how this would work if there were many different employers with many different projects to be carried out because of the resource issues that need to be considered in managing assessments.

Conclusions

The newly launched degree apprenticeship model (notably the manufacturing engineer and digital & technology solutions professional) addresses many of the issues highlighted for reform. The defining attributes of the model[9] has generated much interest from employers to be directly involved in developing the degree apprenticeship or taking on these apprentices. Also, government funding drives employer engagement, particularly having extra incentives for small companies.

It is too early to establish whether these apprenticeships are viewed as a viable alternative to obtaining a degree for very capable school leavers. However, enquiries to the universities involved in the Trailblazers are increasing from this type of school leaver. There is still a poor perception by parents and a misconception that these degrees are 'lower level' than the full-time equivalent. Publicity and time may breakdown these perceptions.

Although the UK is keeping the name 'apprenticeship,' an alternative that may alleviate some of the prejudice associated with it has been highlighted, i.e. 'sponsored.' This is something that NZ may wish to debate.

The Trailblazer concept is extremely powerful in engaging a network of employers, educators and professional bodies, empowered to develop apprentice standards. However, the facilitation and funding of these Trailblazers is crucial to success. A body that represents the sector targeted provides an ideal facilitator.

It is essential that representatives of employers, professional bodies, and education are involved early in developing apprenticeship standards. Also, a collaborative approach between employers and educators in the final synoptic assessment is critical to ensure parties that the apprenticeship has been successful.

It is very important that the Trailblazers are given freedom to define their expectations, with no stipulation of: length of apprenticeship time, qualifications, number, level and delivery modes. This fosters the production of targeted standards and operational models to serve a particular occupation.

The initial goal of the degree apprenticeships was to address the needs of the UK economy, mainly through engineering in the automotive, nuclear and civil sectors and the digital industries. The model seems to offer an attractive proposition to increase the skill base of high-tech firms, particularly those in industries with fast evolving technology.

The authors' view is that the roll-out of the degree apprenticeship has been too quick in England, (i.e. less than 2 years from government announcement to implementation). More time is required to ensure that a wide representation of employers and educators views are heard and that allowance is made for innovation in delivery of the degrees.

SMEs are interested in the degree apprenticeship but full engagement remains difficult. Tertiary education providers that have strong links with SMEs are more likely to succeed in developing a degree apprenticeship programme. An effective network that represents a sector of companies is needed to broker relationships between industry and education sectors.

Education providers are actively designing pathways through to higher levels of learning, i.e. from degree apprenticeships to masters and PhDs. Stair casing is relatively easy in the UK as each provider (i.e. a university) offers all levels of qualifications.

[9] Outcomes based and occupation driven, employers and professional bodies are in the driving seat, purchasing power is given to the employers, the process is 'government light' and left to employers and educators to allow for innovation

Chapter 6 Recommendations

1. **Degree apprenticeships should be implemented as a viable learning model to educate engineering technologists**

   We conclude that well-designed apprenticeships are excellent models for preparing engineers that can cope with the challenges of the future.

   The apprenticeship pedagogy is an effective mode of learning, however learning is not automatic. We recommend an experience-led model in which employers engage with educationalists to ensure effective learning.

   We endorse the apprenticeship as the preferred model for the active engagement of employers. Therefore, we recommend that the Bachelor of Engineering Technology is delivered exclusively through an apprenticeship model.

2. **Government should co-fund these apprenticeships by giving money directly to employers.**

   Our conclusion is that the NZ economy and society at large will benefit from an injection of skilled labour at the engineering technologist level. The Government is a stakeholder, and must bear responsibility for ensuring a viable programme is initiated.

   Employers are a significant beneficiary of technologist training and education and must be prepared to invest in it, while Government must be prepared to financially incentivise employers. Funding through employers puts them in the driving seat.

   There is a "quid pro quo". Employers may specify the skills, knowledge and attributes they expect in a new employee.
   In exchange, they participate in the training of apprentices and contribute to their wages.

   Students must be bonded so as to contribute to the New Zealand economy for an appropriate period of time.

3. **Apprenticeships should be specified by standards, developed as sector or occupation-defined outcomes and targeted towards helping the economy grow. The outcomes should link to sectors with fast evolving technology.**

   Apprentice standards may specify a minimum number of hours (on and off the job) but the main focus should be the achievement of skills, knowledge and behaviour.

   We recognise an opportunity to specify new areas of skill capability required to grow NZ's economy.

4. **A collaborative approach, between employers, professional bodies and Institutes of Technology and Polytechnics (ITPs), should be used in the planning and design of these apprenticeships.**

   A similar model to the UK's Trailblazer project should be implemented in NZ.

   Employers should consist of a representative sample of the sector or occupation, i.e. SMEs must be part of the Trailblazer team.

   The process should be initiated by a Government call for standards to be developed by employers, professional bodies and ITPs.

   The design and implementation of these apprenticeships should follow a carefully planned and considered process. To ensure success, adequate time should be given to the planning phase.

   The identification of key players and the timing of their involvement is crucial.

5. **Degree apprenticeships should have clear pathways to higher-level qualifications.**

   Commitment to a degree apprenticeship must be seen as a means to progress to higher learning.

   Enrolment in an apprenticeship degree must guarantee access to higher degree programmes. Collaboration with universities is therefore critical.

We acknowledge that competition between universities and ITPs is a potential problem. Consideration should be given to 'how and when' (in the design process) ITPs and universities reconcile and agree on pathways. There are two problems that would need to be resolved:

a. Attractive apprenticeship degrees may reduce university first year enrolments.
b. Without university collaboration the pathways to higher level degrees may not eventuate.

We recommend that Government considers incentives for universities to staircase these degrees. Ideally, courses should be designed as complete entities with exit points at diploma, degree, honours degree, masters and PhD.

6. Degree apprenticeships should be marketed as a new Gold Standard for educating engineering technologists

These apprenticeships provide a value proposition to the employer, the student, ITPs and Government that can be easily marketed. Employers are in control of what they will be getting, providing employees with higher-level skills. Earning an income whilst completing a degree, avoiding hefty student loans and gaining valuable industry experience are some key benefits that will attract young people and increase enrolment of engineering students. ITPs can strengthen their links with employers and see growth in student numbers. By following this strategy the Government will create a catalyst for economic growth and reduce student debt.

7. Degree apprenticeships should be named 'sponsored degrees'.

Finally, having delivered our recommendations using the term 'apprenticeship,' we advocate that this term should not be used for this degree. The perception of apprenticeships and apprentice degrees as lesser qualifications is so engrained that the term 'apprentice' should be discarded to attract excellent students. We therefore propose using the term 'sponsored degrees' instead.

Acknowledgements

This report was undertaken with financial support from the Tertiary Education Commission (TEC) in New Zealand.

We're particularly grateful to the Liz Gorb from Manchester Metropolitan University and Kevin Neailey from Warwick University who contributed to this report by giving their time and knowledge.

About the authors

JANE GOODYER

Jane is an Associate Professor in the School of Engineering and Advanced Technology (SEAT) at Massey University. She has extensive experience in engineering education, has conducted curriculum reviews and design, and is an accreditor for the Institution of Professional Engineers New Zealand. She has contributed to New Zealand's National Engineering Education Plan and other initiatives to support engineering education. Jane has previously worked as a manufacturing engineer and still continues to work with companies to help improve productivity. Her initial qualification (BEng Honours) was obtained by a sandwich degree, otherwise termed as a co-op, and so has first-hand experience of the benefits of learning whilst being employed.

THOMAS G. FRATER

Greg is a cross-disciplinary academic with a broad range of academic interests and industrial experience. He worked for more than 20 years in a range of industries including manufacturing (in industrial management and process research) and horticulture (orchard level and post-harvest systems) before joining Massey's engineering programme to teach quality management and other industrial subjects. Greg's PhD (2010) focussed on energy use in apple production.

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