Engineering e2e: An evaluation

Report prepared for the Tertiary Education Commission and the Engineering e2e Steering Group

Karen Vaughan

Tertiary Education Commission
Te Amorangi Mātauranga Matua

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EDUCATIONtoEMPLOYMENT

NZCER
Rangahau Mātauranga o Aotearoa

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Glossary

Acronym	Full name
BE(Hons)	Bachelor of Engineering (Honours)
BEngTech	Bachelor of Engineering Technology
CATE	Careers and Transition Educators
CDANZ	Career Development Association of New Zealand
EFTS	Equivalent Full-time Student
ENZ	Engineering New Zealand
IPENZ	Institution of Professional Engineers of New Zealand
IPWEA	Institute of Public Works Engineering Australasia
ITO	Industry Training Organisation
ITP	Institute of Technology and Polytechnic
MOU	Memorandum of Understanding
NZDE	New Zealand Diploma of Engineering
NZDEP	New Zealand Diploma of Engineering Practice
PPTA	Post-Primary Teachers' Association
SAC	Student Achievement Component
SME	Small to Medium-sized Enterprises
SPANZ	Secondary Principals' Association of New Zealand
STEM	Science, Technology, Engineering, Maths (subject areas)
STP	Secondary–Tertiary Pathways
TEC	Tertiary Education Commission
TEI	Tertiary Education Institution
TEO	Tertiary Education Organisation

Executive summary

Engineering e2e (education-to-employment) is a programme designed to increase the number of engineers in New Zealand. It was established in 2014 by the Tertiary Education Commission (TEC) in response to Government concerns about the possible economic impact of a forecasted engineer shortfall, especially for technicians and technologists (NEEP Project Governing Group, 2010).

The evaluation of Engineering e2e is a high-level review of it as a "systems integrator" that "coordinates, catalyses, and monitors" education-employment activity (Barton, Farrell, & Mourshed, 2013). Through a review of documentation and 16 interviews with steering group members and initiative or project leaders, the evaluation asked two questions:

- In what ways has Engineering e2e acted as a model of systems integration?
- What can be learned that might apply to Engineering e2e in the future and/or to e2e projects in other fields?

Findings and observations

Systems integration is an interpretation, not a blueprint

Systems integration (catalysing, coordinating, and monitoring) is a high-level idea about how best to work, rather than a recipe for exactly what actions to take. Deciding on actions depends on how the system (its nature, its scope) is conceived, and any conception naturally brings some advantages and some trade-offs.

Engineering e2e has a *workforce development* approach to systems integration. That is, it coordinates individual opportunities, organisational goals, and national priorities for economic growth. This is distinct from the former Careers New Zealand's e2e approach which has a *career development* perspective; that is, it has provided information and support to people at all ages and stages in different careers to manage those careers. Workforce development and career development are different approaches but both are strategically important to public policy.

For Engineering e2e, the workforce development approach means "the system" in systems integration is an "engineering pipeline": primary schooling, secondary schooling, tertiary education, and employment. Engineering e2e has focused particularly on the role and capacity of tertiary education in the pipeline—perhaps not surprising given that it is managed by the TEC.

The upside has been a capacity to readily enlist support from stakeholders with a specific interest in engineering. The Engineering e2e Steering Group has reached out to, and been contracted by, many professional associations and tertiary education organisations, and the numbers and spread continue to grow every month.

The downside has been de-emphasis of some of the important stakeholders in the pipeline (e.g. families and whānau, schools). Several interviewees raised concerns about the lack of compulsory schooling sector involvement, and suggested that tertiary education had dominated at the expense of attention to employers and schools. That said, all interviewees thought the systems integrator role was important in principle, even with questions about how the role was interpreted or who was directly involved.

Engineering e2e systems integration achievements

Engineering e2e's explicit goal of 500 more engineering graduates has been achieved, with the TEC confirming 511 engineering graduates from courses in 2016.

There are also a number of supporting achievements that provided the conditions for increase in engineering graduates. These are shown in the table below, broken into the three key areas of catalysation, coordination, and communication. The achievements are adapted from interviewees' comments about their experiences, successes, challenges, and surprises during their Engineering e2e work. They serve as useful examples of what is possible with a systems integration entity.

	Examples adapted from interviewees' comments
Catalysation	Taking a systems view disrupts the accepted idea of competition between providers
	Establishment and oversight of new relationships, leading to opportunity-spotting
	Opening up of "space" through funding and resource for project leaders to work differently and consider possibilities
	Operation outside of business-as-usual sparks possibility in steering group members and stakeholders
	Influential leadership lends weight and creates momentum
	New things tried in curriculum, pedagogy, and pathways in secondary and tertiary education
	Field-specificity attracts stakeholders and sharpens focus
	Raised awareness of engineering careers in general, and specific sub-fields of engineering
	Creation of possibility for changes to credential design
Coordination	Direction and funding to initiatives and projects
	Liaison and interaction with stakeholders: tertiary educators, employers, professional groups and peak bodies, and government agencies
	Oversight of, and guidance for, partnership projects that enable changes to curriculum, pedagogy, pathways
	Oversight of new pathways to provide clarity and flexibility to stakeholders
	Cross-organisation groupings create new or deeper understandings, and some new alignment possibilities
	Steering group leverages networks
Monitoring	More understanding of the implications of data among project leaders and steering group members
	Development of new communication channels that pull together, and clarify, information *from* multiple sources and stakeholders, *for* multiple stakeholders.

Engineering e2e has an emergent dimension that fosters relationships for change

Although Engineering e2e has three broad work streams set by the TEC, it is the steering group that gives effect to these. This occurs through 12 different initiatives centred on education design and delivery (e.g. credentialling, curriculum, pedagogy), career promotion and public perception, and employer engagement. Significantly these initiatives were not set from the start; they have been shaped and commissioned along the way. This gives Engineering e2e a strong emergent dimension, making it unusual as a group with government funding.

Engineering e2e is also unusual in being a partnership across education and employment sectors, while managed by one government agency. Steering group interviewees saw value in being part of something that was not business-as-usual and not "owned" by one organisation. They liked the collaborative approach. They valued having a mandate to try different things.

All interviewees cited the formation of new relationships or strengthening of existing ones as key to achieving success. Relationships were constantly being generated and reworked, as new groups and members were brought into the Engineering e2e fold. Interviewees reported that these relationships, sometimes "hard-won", enabled new or deeper understandings, fostered ongoing open communication, and created collaboration possibilities. Project leaders emphasised the role of funding in freeing up their attention to see the bigger picture and imagine different ways of working. New initiatives were explored and designed as alignment possibilities opened up.

Operating below the radar may not lead to change that is self-sustaining

The risk of Engineering e2e's emergent aspect has been that organisational commitments and operations may remain largely unchanged because challenges to them are not made explicitly or are not made in terms that would make sense for the more typical model of advance planning used in most organisations. Many interviewees understood Engineering e2e, and their work in it, to be about going "rogue" or operating "below the radar" in order to achieve things.

Project leaders cited working the boundaries and accountabilities of their own institutions and organisations, including where current TEO settings discourage collaboration. Steering group members cited thinking beyond their organisation's immediate concerns (e.g. recruiting employees or students, or promoting the interests of business or a professional association) to national goals and needing to harmonise that with the groups they represented.

This dual positioning is inevitably awkward. At times interviewees spoke as representing the entity of Engineering e2e through their engineering project or the steering group. At other times they spoke as representing their own organisation's interests, sometimes in order to criticise Engineering e2e. The challenge of representing an organisation's interests and aligning those with others is fraught all in cross-disciplinary or cross-agency initiatives. It is therefore almost impossible to over-estimate the need for open and ongoing communication and the work needed to build shared understandings *and* surface the differences that create the space for innovation.

Sustaining systems integration long-term will involve dealing with conflicting measures of success between different stakeholders. It will also involve working out how to continue the work if and when personnel changes occur. All interviewees saw value in realigning their work with the work of others—or in trying to achieve the reverse. But most interviewees were not confident that this could happen without designated resourcing and a designated entity acting as a systems integrator.

The idea of having a systems integrator might suggest that success could be judged in terms of changes being embedded across the system. However, equally it might be that there is a continuing role for a systems integrator that prompts and sustains relationships, and helps counterbalance any self-interest connected to the incentives and constraints of an imperfect system.

Conflicting perspectives on demand and vocational education undercut achievements

Although Engineering e2e achieved its target of 500 more engineers a year, it did not achieve the underlying intent to have more of the kind of engineers most needed. The 2010 National Engineering Education Project (NEEP) report argued for, and quantified, a need for engineering technicians and technologists. However, enrolments at level 6 (for engineer technicians) and level 7 (for engineer technologists) have dropped by 6–11%, and enrolments at level 8 (for professional engineers) have increased by around 20% (TEC Operations Directorate data, August 2017).

The problem lies with how "demand" and pathways are perceived by different stakeholders. The NEEP report and Government framed demand in broad economic terms. However, other stakeholders framed things differently. The public, students, and families and whānau were interested in marketability and long-term career opportunities. This was understood as best achieved through a high-esteem pathways and qualifications, i.e. a university pathway towards a level 8 qualification for professional engineer status.

Some employers, particularly small-to-medium-sized enterprises (SMEs), favoured professional engineers (qualified at level 8) over technicians and technologists because of the nature of their business, the way jobs were structured, and the scope of work that can be covered by a professional engineer (but is restricted for technicians and technologists).

New Zealand has long-standing perceptions about vocational education being second best, as well as a predominance of SMEs, and a history of very little coordination between education and employment sectors. None of this is of Engineering e2e's making but it has made its task very difficult. It also explains why Engineering e2e's public awareness campaign did not make all the ground expected and probably inadvertently helped increase enrolments for professional engineer qualifications at the expense of enrolments for technician and technologist qualifications. As individuals and families gained more awareness of engineering careers, they sought the best return on an investment in them—a return reinforced by many small employers.

(Near) future focus possibilities in career development and diversity

From the beginning there has been an assumption that a need for more engineers (of any kind, at any level) can be met by having more people train and qualify as engineers. As with other occupations such as teaching, it is possible to have pipeline leakage occur soon after qualification or employment. It may now be worth Engineering e2e turning some of its attention to the retention and professional development of qualified engineers. Although career management has not been a focus so far, there is potential for it within Engineering e2e's existing initiatives. This could be linked up with the existing work on engineering capabilities started through the Growing the Pipeline initiative.

Engineering e2e is competing with other industry areas for a pool of school leavers that has been reducing for the past 5 years. This suggests that one initiative that did not get underway over the past 3 years—Growing Through Diversity—might arguably be an especially important one. It offers potential to recruit and develop people who are not the same as the current crop of engineers. The Secondary–Tertiary Pathways projects have made some in-roads by increasing the interest, and enrolment, of women, Māori, and Pasifika. A more diverse group of people entering engineering might well add great value to the industry and New Zealand's economy.

SECTION ONE

Introduction to Engineering e2e and this evaluation

Engineering e2e

Engineering e2e (education-to-employment) is a programme designed to help increase the number of engineers in New Zealand by working within and across the education-to-employment system—compulsory schooling, post-school education, and employment environments, which together have become known as the "engineering pipeline". Engineering e2e was established by the Tertiary Education Commission (TEC) in June 2014 following a request from the New Zealand Government, concerned about the economic impact of emerging and forecasted engineer shortages.

Engineering e2e's fundamental aim has been to ensure New Zealand produces an additional 500 engineering graduates per year from 2017. Engineering e2e has approached this aim through three broad work streams set by the TEC. A steering group gives effect to those work streams through 12 different initiatives, some involving multiple projects. The initiatives are designed to address different aspects of the engineering education-to-employment system, such as: education design and delivery (e.g. credentialling, curriculum, pedagogy), career promotion and public perception, and employer engagement.

Structure

The TEC has management oversight of Engineering e2e, including approving the spending of its budget. A steering group runs the Engineering e2e programme and makes decisions about new initiatives. The steering group meets monthly to provide advice and guidance on initiatives and projects, and leverages group members' links with other Engineering e2e stakeholders. The work streams were decided at the beginning. However initiatives have been and continue to be framed up, commissioned or sought, along the way. In this sense, Engineering e2e has a strong emergent dimension, making it unusual as a group with government funding.

Membership of the steering group has changed between 2014 and 2017, as different members have come and gone. However, membership has always been conceived as a partnership between the Institutes of Technology and Polytechnics (ITPs), Engineering New Zealand (formerly IPENZ, the Institution of

Professional Engineers of New Zealand), Business New Zealand, and organisations employing engineers. In addition to the original partners, the steering group includes one university representative, one representative from the standards-setting body (NZBED) for the level 6 New Zealand Diploma in Engineering (NZDE) and the level 6 New Zealand Diploma in Engineering Practice (NZDEP), and one Industry Training Organisation (ITO) representative. Steering group membership is currently made up as shown in the following table.

TABLE 1 **Steering group membership as at December 2017**

Role or organisation type	No. reps
Chairperson	1
Employer	6
Business New Zealand	1
Engineering New Zealand[1]	1
New Zealand Board of Engineering Diplomas (NZBED)	1
Industry Training Organisation (ITO)	1
Institutes of Technology and Polytechnics (ITP)	3
Tertiary Education Commission (TEC)	1
Universities	1

Engineering e2e is also advised by two other groups: an Engineering Reference Group made up of engineering educators from ITPs, and an Industry Advisors Group which helps the steering group identify and share case studies of good practice.

Engineering e2e has established links, or had interactions, with many stakeholders through its initiatives, projects, and advisory groups, and more recently also through several Memoranda of Understanding. In the main these stakeholders include employer and industry groups, Tertiary Education Organisations (TEOs), government agencies, and professional organisations such as engineering peak bodies.

Work streams and initiatives

Engineering e2e's three broad work streams are: Marketing and Promotion; Educational Delivery; Industry Partnerships. The 12 initiatives within these are shown with in the following table. Note that Secondary–Tertiary Pathways initiative contains six different projects and partnerships. Two initiatives—Growth Through Diversity and Engineering Education Hubs—are yet to get fully under way.

1 Up until December 2017, Engineering New Zealand was known as the Institution of Professional Engineers of New Zealand or IPENZ.

TABLE 2 **Engineering e2e initiatives**

Initiative	Brief description
Secondary–Tertiary Pathways (STP) Projects Collaborations between secondary schools and Tertiary Education Organisations (TEOs). ITPs lead all of the STP projects.	Wintec: school–Wintec programme; holiday and professional development programme for school teachers; school programme offering standards for tertiary engineering study. Ara Institute of Canterbury: school course taught by Ara staff; school student visits to Ara and local industries. WITT: school course with credits towards New Zealand Diploma in Engineering; taster course with special focus on engaging female, Māori, and Pasifika students. Otago Polytechnic: project-based NCEA modules; learning resource kits developed for nationwide use; careers events; problem-solving course. Northtec: tasters leading to 2018 programme for entry to New Zealand Diploma in Engineering and cadetships with engineering firms; engineer mentors for students. Unitec: partnership with engineering firms and schools co-creating and co-delivering courses for entry to New Zealand Diploma in Engineering or Bachelor of Engineering Technology; professional development for school maths and physics teachers.
Sponsored Degrees	Exploration/development of models of delivery (especially for rapidly changing, high-tech industries) which allow on-the-job training and completion of level 7 qualification.
Micro-credentials	Research into micro-credentials (smaller than conventional qualifications) that could provide students, employers, and TEOs with more flexibility, better information, and support innovative course mixing and matching. Pilot projects will follow.
Growing the Pipeline	Research based on the workshop introducing industry leaders to the Graduate Capability Framework, which may facilitate more industry–educator collaboration to improve engineering programme relevance.
Engineering Education Hubs	In development: regionally-based engineering education centres which involve employers, high schools, universities, Institutes of Technology and Polytechnics (ITPs), and Industry Training Organisations (ITOs).
Employer Resource Portal	A resource portal giving employers access to the latest tools, good practice examples, and guides to recruit, retain, and grow employees.
Communications to employers	A communications plan to raise awareness of the value of diploma and 3-year degree graduates amongst small-to-medium firms, particularly in regional locations.
Growth through Diversity	In development: proposed research on how to boost numbers of women, Māori, Pasifika, and other groups in the engineering workforce, with input from other stakeholders.
Public awareness campaign	Make the World campaign to raise interest in engineering careers and study options.
Management	TEC staff who consult with stakeholders and oversee the development and implementation of Engineering e2e initiatives.
Steering group	The group that leads Engineering e2e and gives effect to the goals and work streams, engages with stakeholders, and helps form industry–education provider partnerships.
Website and communications	Publishes material such as case studies, research reports, and regular newsletters so that stakeholders are familiar with Engineering e2e initiatives.

Evaluating Engineering e2e

The purpose of this report is to evaluate how Engineering e2e has been working as a "systems-integrator"—an entity that "coordinates, catalyses, and monitors" education–employment activity (Barton, Farrell, & Mourshed, 2013).

The two questions addressed in the evaluation are:

1. In what ways has Engineering e2e acted as a model of systems integration?
2. What can be learned that might apply to Engineering e2e in the future and/or to e2e projects in other fields?

The evaluation is based on two main sources of data:

- documentation from 2014–17, such as steering group meeting minutes, background papers, and work plans.
- interviews with 16 people who were steering group members or leaders of projects funded by Engineering e2e.

Interviewees were selected by Engineering e2e to represent a range of interests, viewpoints, and stakeholder organisations. A 17th person declined to provide a formal interview but spoke informally. Interviewee roles were spread as shown in the following table.

Role		No.
TEC management	TEC representative	2
Steering group	Chairperson	1
	Employer/business representatives	3
	ITP representatives	1
Initiative or project leaders	Secondary–Tertiary Pathways projects	4
	Other initiatives	5
	TOTAL	**16**

Most interviews were conducted by telephone and took around 30 minutes. The interview questions focused on:

1. what had been achieved *as a result of* their Engineering e2e project or their steering group membership
2. anything else (not necessarily linked with Engineering e2e) that helped achieve these things
3. anything else (positive or negative; unexpected or confirming) that occurred as a result of participating in Engineering e2e
4. what they had learned from participating in Engineering e2e
5. the biggest barriers to continuing with a systems-wide approach if there were no Engineering e2e
6. any advice for a stakeholder group embarking on e2e initiative in a different field
7. anything else they wanted to comment on.

Interviews were conducted on the basis of individuals' confidentiality being maintained. Individuals were also promised that they, and/or their organisation, would not be identifiable in subsequent reporting, discussions, or presentations. Pseudonyms for individuals are used throughout this report.

In most instances, interviewees spoke from the perspective of the entity of Engineering e2e—for example, about the goals "we" had in Engineering e2e. However, sometimes steering group members or project leaders responded to interview questions from the perspective of their organisation or industry area—for example, the goals "we" had in my organisation. This is understandable, but means those comments are about the extent to which Engineering e2e outcomes to date have benefitted the area they represent, rather than the overall goals of Engineering e2e. Where an industry or organisation perspective is used and/or is not obvious, clarification is made using square-bracket insertions in quotes.

The evaluation provides a high-level examination. It does not examine the parts (the initiatives, reported on elsewhere[2]) but rather the sum of those parts. After 3 years, what have we learned about Engineering e2e's systems integrator approach that might inform its future and/or the potential for e2e initiatives in other fields?

2 The website hosts reports work plans listing projects and their goals and success indicators. and specific project reports (e.g. case studies, progress updates, research findings). See in particular Newsletter No. 38 (December 2017) which lists projects and achievements to date.

SECTION TWO

Systems integration and the pipeline

Engineering e2e origins

Engineering e2e originated in the Government response to a National Engineering Education Plan (NEEP) project funded by the TEC in 2008. The NEEP project considered engineering pathways from school and through tertiary learning, engineering qualifications, and coordination of tertiary education providers. In 2010 it reported the estimated demand for—and supply of—engineers, and future demand for engineering graduates, based on data from the former Department of Labour, the Ministry of Education, the OECD and feedback from industry (NEEP Project Governing Group, 2010).

The report showed shortfalls in the number of engineers needed for two different scenarios—one for business-as-usual and one for an innovation-led economy. In both scenarios the shortage was reported as acute for technicians and technologists, respectively requiring qualification at level 6 and level 7 on the New Zealand Qualifications Framework. While there was a forecast shortage of professional engineers (requiring qualification at level 8), this was nowhere near as serious as for technicians and technologists.

The report recommended that future planning be based on the estimated demand for engineering graduates, especially at levels 6 (NZDE) and 7 (BEngTech) and that the TEC allocate funding towards engineering programmes. It also recommended ongoing work between ITOs, the Ministry of Education, and the TEC to develop school-to-employment pathways.

In response, the Government allocated an additional $42m over 4 years in its 2012 Budget, with a further $9.3m in 2013, for maintenance of the quality of education provision for engineers and to increase the number of engineering graduates. A target of an additional 500 graduates per year from 2017 was set. Engineering e2e was allocated around $6m for its work in pursuit of this target.

The TEC followed up the NEEP report with another report, Growing the Engineering Pipeline (Tertiary Education Commission, 2013). This provided an overview and analysis of initiatives and issues in increasing the number of engineering graduates. Issues included that secondary students who aspired to engineering were not well prepared for tertiary learning. Their chosen school subjects did not allow them to meet entry criteria, they were unprepared for learning at tertiary level, and they did not know about engineering work and career options.

The NEEP report and Growing the Engineering Pipeline were important precursors to Engineering e2e. As it was set up in June 2014, it took up the target of 500 engineering graduates per year from 2017, seeking further specificity within that number (steering group minutes August 2014) and re-validating the overall target through a NEEP Reference Group meeting in November (steering group minutes, December 2014).

Coordination, catalysation, and monitoring

Engineering e2e's conception as a *systems integrator* was prompted by the McKinsey Centre report, *Education to employment: Designing a system that works,* which described a need for such an entity to "coordinate, catalyse, and monitor" education-employment activity (Barton, Farrell and Mourshed, 2013). Hence Engineering e2e aspires to produce more engineers through integrating education and labour market sectors involved—what has become known in Engineering e2e and the TEC as "the engineering pipeline".

Although not a report specific to New Zealand, the McKinsey Centre report captured situations and issues that apply here. The idea of systems integration through coordination, catalysation, and monitoring of activity is essentially a high-level one about how best to work, rather than a recipe for exactly what actions to take. So what systems integration looks like depends partly on the existing systems in place and the way problems with these are defined. In this case, the problem of not enough engineers—especially at technician and technologist levels—is defined in labour market alignment terms, locating it in relation to a set of issues familiar to many OECD countries:

1. under-employment and skills mismatches (e.g. between jobs and field of study or between jobs and qualification level)
2. gaps in provision of career information and advice
3. lack of clarity and/or flexibility in pathways to jobs or into industry areas
4. misalignment between the interests of different sector stakeholders (e.g. between secondary and tertiary education or between tertiary education and industry)
5. labour casualisation, precarious work arrangements, and "future of work".

Engineering e2e engages directly with the first four points above. The fifth point is not a focus but may well be associated with the others.

Drawing on research into these issues from around the world, the McKinsey report offered a range of high-level suggestions about education-to-employment systems. These have been adapted into the following table, showing what coordination, catalysation, and monitoring might look like.

TABLE 3 **Possible coordination, catalysation, and monitoring activities**

Coordination	Catalysation	Monitoring
Connect together and support stakeholders to ... • collaborate and co-design activities, priorities, and outcome measures • consult with and advise each other • build new relationships • re-align priorities and success indicators • share and use data meaningfully • create cost-sharing arrangements	Prompt stakeholders to undertake activities ... • for the first time • in new or different ways than before • with a system-wide view	Monitor data or information produced by stakeholders and ... • set up and use channels to communicate with stakeholders • enhance or create new understandings or awareness • make the situation and issues transparent to stakeholders

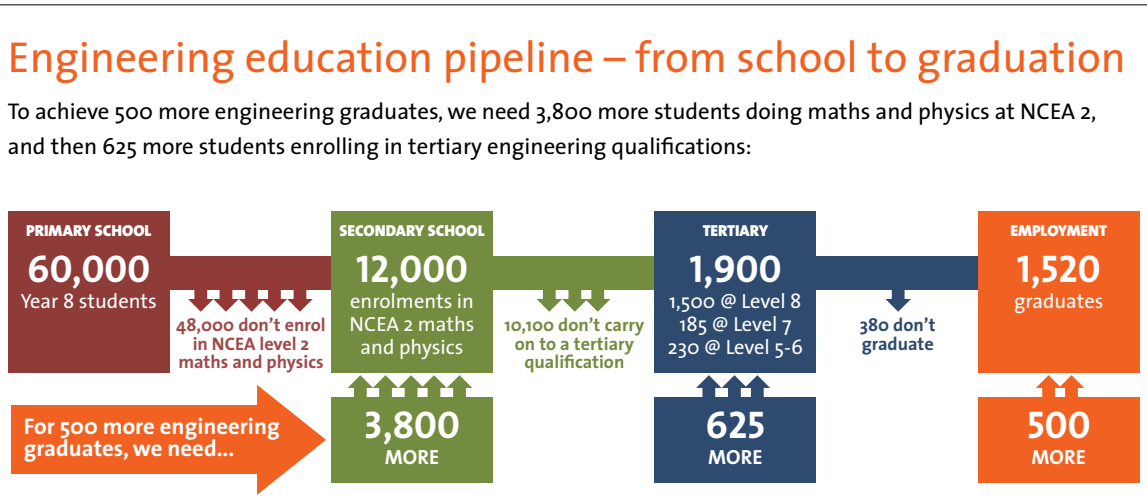
The pipeline

The activities of coordination, catalysation, and monitoring are designed to create alignments that can be seen in terms of "job vacancy alignment" and/or "skills alignment" (Cleary & Van Noy, 2014). Engineering e2e origins, and its high-level, primary aim, are job vacancy alignment ones—matching the number of graduates with the demand for workers with those credentials, and increasing the number of graduates in specific areas to meet future demand for workers. However, Engineering e2e also oversees several initiatives (e.g. Growing the Pipeline and Micro-credentials) that have a skills alignment focus—aligning skills, competencies and credentials in tertiary education with those most in demand in the labour market.

The tricky thing is that getting the correct numbers (e.g. 500 additional graduates per year) for job vacancy alignment, and the right skills for skills alignment, may mean different things to different stakeholders. In Engineering e2e's case these stakeholders are both internal (steering group and TEC management) and external (e.g. students, schools, policy managers in different agencies, the public, engineering businesses). And their needs and interest exist within an environment that continues to evolve.

It is therefore important to grasp the way "the system" is defined by Engineering e2e as a "pipeline". The following figure reproduces the Engineering e2e conception of the pipeline.

FIGURE 1 **The Engineering e2e Pipeline**



There are around 10 projects sitting within the initiatives that are designed to effect structural change to curriculum, pedagogy, and/or qualifications: Growing the Pipeline (graduate capabilities work), Micro-credentials (which may spawn several pilot projects), Sponsored Degrees, and six Secondary–Tertiary Alignment projects. The remaining eight initiatives focus on communications and resource provision (e.g. Employer Resource Portal, Communications to Employers, Public Awareness Campaign, Engineering Education Hubs, and Website and Communications), or on management and operations (Management and Steering Group), with one initiative yet to get underway (Growth Through Diversity).

Nearly all of the initiatives reflect a strategic decision to focus on the third part of the pipeline—tertiary education. Secondary–Tertiary Pathways projects are collaborations between TEOs and secondary schools, but all six are led by TEOs. The Micro-credentials and Sponsored Degrees initiatives are likely to have a strong focus on the Employment part of the pipeline, and there is scope for Growth Through Diversity to do so as well.

The system

Research and recent trends have highlighted that the settings, conditions, and timeframes in which people actually learn and make career choices are much wider than the formal education system—for example, access to Massive Open Online Courses (MOOCs) and the expansion of work-integrated learning (WIL), and recognition of current competency (RCC) models. In this sense, "the system" is lifelong and life-wide, involving a myriad of combinations of formal and informal learning experiences and people's changing motivations and priorities (Falk et al., 2015).

However, if the system is conceived as a "pipeline", the focus is very much on the formal education system in schools, TEIs, and workplaces (e.g. cadetships). This keeps Engineering e2e's scope fairly narrow and tight (i.e. closely matched to the needs of employers) and strongly linear. However, there is still some space for initiatives to take a slightly broader view. For example, the public awareness campaign and some STPs engage with families and whanau as career influencers, and the Micro-credentials and Sponsored Degrees initiatives allow for pathways that are not necessarily linear.

Careers New Zealand and Engineering e2e as different kinds of systems integrators

Engineering e2e is not the only entity trying to act as a systems integrator in New Zealand. The former Crown Entity, Careers New Zealand (part of the TEC since July 2017) has also attempted to do this work. One way to understand the differences between them is to consider their different lenses on systems integration: *career development* (career interventions for management of careers and learning throughout life, not just at early decision-making stages) versus *workforce development* (coordinating individual career opportunities, employer goals, and national priorities for economic growth).

Careers New Zealand engaged with some of the misalignment issues common across OECD countries, particularly lack of pathway clarity and gaps in provision of career information and advice. Its *career development lens* reflected the growing strategic significance of careers work in public policy. This signalled an important shift from vocational guidance focused on initial career decisions and linear career progression to a focus on helping people *manage* their careers throughout life.

Hence Careers New Zealand provided an all-age, all-careers information and support service to individuals and families and whānau. In particular it has focused its efforts on its website-based information and resources, and on providing professional development to schools and TEIs so they could better support students. Importantly Careers New Zealand was independent and not associated with any particular industry areas or fields of practice.

Engineering e2e's *workforce development lens* applies to a specific field (engineering). It is then able to enlist the involvement of a range of stakeholders in support of a goal that connects very directly to their needs. For example it can impact on secondary and tertiary students looking for career opportunities; industry peak bodies wanting members and a sustainable workforce; employers needing to recruit employees; secondary schools trying to develop clear pathways; and TEIs needing enrolments and to demonstrate their credibility with industry and the public.

These different approaches to systems integration—based in career development or workforce development—are just that: different. Their different angles and drivers mean that they engage with different groups of stakeholders, though with plenty of overlap, but do it in different ways and to different ends or measures of success.

Engineering e2e's workforce development approach to systems integration means it really has two levels to its goal. The surface aspect of the goal (500 more engineers qualified each year from 2017) has an

inputs/outputs focus. This is consistent with the idea of a linear pipeline and has the advantage of being more easily grasped and measured.

The deeper, underlying aspect to Engineering e2e's goal (more engineers to ensure New Zealand's innovative economy into the future) comes closer to working with the idea of a complex, adapative system. The dynamic interactions between different parts of the system, and unpredictable opportunities and constraints emerging from these interactions, are what Engineering e2e faces in reality. This includes that its goal is actually a contestable one, depending on the views and interests of the many different stakeholders in the system.

SECTION THREE

Achievements with Engineering e2e

Most interviewees acknowledged Engineering e2e's achievement in contributing to an increase in engineering graduates, including reaching the goal of 500 more per year (due in 2017 but reached early). The STP project leaders were most enthusiastic and, perhaps not surprisingly, they focused on their own initiatives and projects rather than Engineering e2e as a whole. Steering group members were enthusiastic about the overall Engineering e2e entity. The employer/business representatives were least enthusiastic.

Project leader perspectives

A major focus for Engineering e2e was on catalysing a range of initiatives. First, Engineering e2e gave impetus, direction, and funding to projects that were already conceived or were at an early stage of implementation. Secondly, Engineering e2e instigated entirely new initiatives and projects. Several are informal at this stage in that they took the form of Memoranda of Understanding (MOU) to work together for aims which come under the auspices of Engineering e2e.[3]

Interviewees who led projects did cite project-specific achievements that they thought were, either wholly or at least in part, due to support from Engineering e2e. The achievements and activities associated with each project are well documented on the Engineering e2e website. Interviewees were therefore only asked to briefly describe these achievements as part of a broader discussion about the significance of the achievements. They were also asked about any additional or unforeseen impacts, and anything they had learned along the way.

Increased understanding of their place in the wider system

Project leader interviewees cited an increase in their understanding of the engineering pipeline as a whole and where their project fitted. Several had had the opportunity to learn more about the nature of engineering work and the different sub-fields (Greg; Apera). This allowed them to improve their organisation's work and provide more value to their stakeholders; for example, better engaging secondary school students with "honest recommendations" about engineering careers (Mike) and giving industry a clear picture of where they can help (Greg).

3 Some of these were signed during the course of this evaluation and may well have evolved into new projects by the time this report is published.

Several project leaders discussed leveraging the influential sponsorship and leadership of Engineering e2e. They described citing the former Minister's continuing support to their networks to encourage partnerships, and to young people and their influencers (e.g. teachers, parents, community) to encourage enrolment in tertiary level engineering programmes. With stakeholders, "The moment they see the government acting on something, that helps" (Greg).

Space to think differently

STP interviewees in particular were grateful for Engineering e2e funding. They described the benefit of having "the resource of time to talk to others" (John) and the space to consider possibilities that would normally be out of scope or difficult to pursue while managing business-as-usual demands in their own organisations.

> We had an opportunity to look at different models of delivery … to think further ahead about what else we could be doing. We always did tasters with trades but now we focus on NZDE. Schools are now approaching us. (Michelle)
>
> We had a chance to be [engineering] programme-specific—something that is beyond the scope of Student Achievement Component funding or institution-wide marketing funding. (John)
>
> We created a platform to share good practice which ideally is done but it's done informally and it does not penetrate well into other areas. This opens up new collaboration possibilities. The funding allowed us to free people up. (Greg)
>
> [There are] things which might happen informally through goodwill and extra work. But Engineering e2e paid for someone to have a specific function to undertake these activities. And that has enabled cross-pollination [of ideas]. (Mike)
>
> Engineering e2e has built our understanding of the wider picture. It has enhanced my executive thinking and planted seeds of ideas to think about doing things differently at an institutional level. (Chad)

Project partner relationships built

The STP project leaders in particular were pleased with relationships strengthened or newly initiated through Engineering e2e. They described relationships as pivotal to the success of STPs.

> It's all about the people. All my events are based on relationships with the careers advisors. I relationship-build fulltime without having to teach … The relationship-building is the biggest part. You don't need exact subject knowledge, though it's helpful. You do need project leaders who are intelligent enough to understand industry, and who are personable and versatile. (Mike).

One project leader described a virtuous circle of purposes and relationships. Having authentic engineering problems for students to work on through the project led to being able to bring in industry, creating "an *authentic* connection" (Michelle). The project's authenticity of purpose made the relationship possible and these relationships were at the heart of generating the necessary buy-in from all partners in the project.

> I was at the [another agency prior to this] … and could just make things happen [at a distance] and didn't worry about intricacies. I now realise it's different on the programme side of things. I now experience [the challenges] first-hand. ITPs used to get me in when having trouble connecting with schools. Now *I* experience that. The challenge of keeping the interest of schools is integral. ITPs can come up with all sorts of things, but without buy-in from schools, it doesn't work. It's about listening and co-construction. (Michelle)
>
> [Having relationships means] there are now conversations between the university and the ITP. And we talk to people in industry. And we are doing STEM work with younger students. (Chad)

Several other project leaders described having their assumptions challenged by virtue of getting to know others and understand their role in the system. These changed perspectives were also typically cited as a significant project achievement in and of themselves.

> I learned more about challenges for schools and built better relationships with them. My attitude towards high schools has changed. I thought their shutters would be down. But high schools are hamstrung by the system; they're not hamstrung by the teachers within that system. Teachers are passionate about kids and their outcomes. If you give them an outlet, they really try. (Frank)

Representatives from organisations which recently signed MOUs with Engineering e2e referred to their entry into a network. For them Engineering e2e "provided the right contacts and facilitated dealings" (Shane) and helped them "realise we are not alone, we see the big picture, and we've been put in touch with the right people" (Laurie).

Steering group perspectives

Steering group members commented on the achievements of the steering group and Engineering e2e as an entity.

Increased numbers of engineering graduates

Steering group members cited the achievement of 500+ engineering graduates. Several were pleased with the way that Engineering e2e had raised awareness about different kinds of graduates, types of engineering, and career options (Mona; Josh; Bo). Another saw the website as a rich resource (Beth). One felt that exploring engineering graduate capabilities was particularly valuable as different engineering sub-fields and expectations about the work emerged (e.g. many engineering roles now have a customer-facing aspect) (Josh).

Facilitating alignment

Both management representatives and several steering group members commented on having seen how Engineering e2e had enabled central government to work across different areas of interest to make connections, raise awareness, and drill down in particular issues. Engineering e2e was seen as facilitating more alignment at a national level and more agreement about the issues between individual education providers and the TEC (Ravi).

Two interviewees felt that this alignment focus had also been given impetus by the Productivity Commission's report (2017). The report helped establish an understanding of the context for Engineering e2e (e.g. the lack of careers information and guidance for secondary school students; the structural constraints on innovation in TEOs).

Cross-organisation incubator or Trojan horse?

Interviewees described being able to create a different kind of cross-organisation group, with a common vision involving both educators and employers, who contributed and worked together to join the dots (Mona; Josh; Donald; Lance). Another interviewee referred to Engineering e2e as the creation of a profile to draw in others, as evidenced by MOUs with Institute of Public Works Engineering Australasia (IPWEA) and Fire Engineers (Lance).

Engineering e2e was variously described by interviewees as being "collaborative think tank" (Apera) and as taking an "incubator" (Mona) approach. They saw it as distinguished by its focus on being "collaborative rather than corporate" (Apera) and for its strong engagement with employers. They also readily saw it as a model with potential to work elsewhere.

Interviewees thought many of Engineering e2e achievements—even just being able to form such a group—was possible because Engineering e2e sat outside of the TEC's business-as-usual work and represented "a break from bureaucracy" (Lance). They saw benefits in sidestepping some of the constraints of being within one agency. However, this may well be a double-edged sword. One interviewee described Engineering e2e as being "a Trojan horse" (Mona) and another described it as "rogue" (Donald). This choice of language suggests something exciting and edgy about Engineering e2e. It may also suggest that interviewees did not see their priorities supported, or goals facilitated, within current structures.

Steering group relationships built

The different initiatives and projects overseen by the steering group are designed to operate through the creation or strengthening of relationships; for example, partnerships and stakeholder buy-in. And the steering group itself is a microcosm of these relationships. So understanding what happens at steering group level may help with understanding what happens in other areas.

One interviewee thought the steering group was a useful sounding board because they brought perspectives ranging from healthy interest to healthy scepticism. "They push back and reshape", he said. Another described steering group relationships as "hard-won" and thought relationships had deepened through working on things such as a contribution to the Productivity Commission's Review of Tertiary Education (Beth). Another interviewee felt the steering group had been able to grow their collective understanding of different types of students and had developed better insights into who is already studying engineering (Ravi).

Most interviewees recognised the value of having a high-profile and influential chairperson at the helm of Engineering e2e. Several claimed this was key to attracting support and raising the profile of Engineering e2e with stakeholders. The chairperson's ability to talk frankly with the former Minister was also cited as key.

Headlines

- Project leader interviewees emphasised the role of funding in freeing up attention to see the bigger picture and imagine different ways of working.
- Steering group interviewees emphasised the value in being part of something not "owned" by any one organisation, and having a collaborative approach with a mandate to try things.
- All interviewees picked out new or stronger relationships as the key to success because it was the relationship that enabled new or deeper understandings, fostering open communication and creating collaboration possibilities.
- All interviewees saw value in realigning their work with others—or vice versa.

SECTION FOUR

Emerging and ongoing challenges

Most interviewees raised emerging and ongoing challenges for Engineering e2e, including for their projects and/or "the pipeline" more generally. Nearly all interviewees made these comments within the context of making other, positive comments about their experience of Engineering e2e. However, there was widespread acknowledgement that the work of collaborating to create more education-to-employment alignments could be tough going as well as inspiring, and that it took a long time to achieve anything.

More graduates ... at unintended levels

While recognising it has contributed to the goal of another 500 engineering graduates per year, the steering group has been open about the fact that these graduates "were not in the right place" (Lance). TEC data on engineering EFTS (Equivalent Full-time Students) shows that, since the inception of Engineering e2e in 2014, enrolments at levels 6 and 7 have dropped by 6–11% and enrolments at level 8 have increased by around 20% (TEC Operations Directorate data, August 2017).

Steering group minutes (31 May, 2017) acknowledged achieving the goal of 500 additional engineering graduates. They also noted "we still need to address the lack of level 6 and 7 qualifications" and wrote about this to the former Minister. An information sheet was produced, spelling out the numbers of graduates needed, the role of ITPs, and profiling several level 6 and 7 graduates (Our Shortfall in Producing ITP-Educated Engineers, June 2017).

Steering group interviewees saw the over-production of BE(Hons) or 4-year degree graduates as connected with seemingly intractable esteem issues associated with particular pathways in the form of certain institutions and qualifications. And almost every interviewee, steering group member, or project leader commented on those issues as part of discussing what they learned and any unexpected experiences and outcomes. Two interviewees summed it up this way:

> The actual outcomes we [the steering group] set out with haven't been achieved. It has raised the profile of professional engineers in universities but there has been no substantive change in perceptions associated with the NZDE and the BEngTech, or the providers that offer them. (Ravi)
>
> University [enrolments] have gone up but not ours [in my organisation]. In the marketing initiative, the clear message was not to identify specific qualifications. And we [at my organisation] said all the way along that it was a mistake. Because it doesn't highlight that you can do degrees and diplomas at polytechs. (Greg).

Perceptions of esteem about qualifications

Several interviewees picked out perception of qualifications as an issue. They referred to the "status quo bias" and "elitism" (Bo) that meant the 4-year degree (Bachelor of Engineering) was favoured by the public, ENZ, and the engineering sector generally (Pierre; Josh). One interviewee felt that the 3-year Bachelor of Engineering Technology degree was considered second class by the peak body, ENZ, and that it did not fit well with their menbership categories (Josh). This interviewee pointed to the greater recognition for the 3-year degree shown in the UK. Perhaps, they wondered, Engineering e2e was simply "flogging a dead horse" over the Bachelor of Engineering Technology.

> If people don't understand the BEngTech and quality is low, or employers don't want it, should it still be a thing? We're talking about a qualification that has been around for 15 years. Why are we still having these conversations about people not understanding it? (Josh)

Although it is early days, the very recent name change of ENZ, formerly IPENZ—the Institution of *Professional* Engineers (emphasis added), may create a signal about esteem. The name change purpose puts the engineering industry in the foreground (moving categories of membership to the background). This *might* lead to more recognition of the full range of engineers; for example, engineering technician members as well as the more established professional engineer members.

Perceptions of esteem about providers

Several other interviewees picked out perceptions about education providers as the issue. They referred to ITPs being widely understood as "second-rate" (Frank) in comparison with universities. One STP project leader cited his disappointment about the choices made by school students, who he described as initially "excited about the prospect of polytech engineering, only to be convinced by their parents to go to university" (Frank). This raises an interesting issue about the interplay of influences and who does, and should, choose—for example, should it be the student, their family, school teachers, an ITP, or a programme advocate?

Another STP project leader reported that some teachers seemed to have "tunnel vision of their own creation", having little understanding of ITPs and a more thorough knowledge of universities. "We're constantly inviting them to visit but you have to drag them" (Michelle).

A third STP project leader saw their role as having a political dimension, feeling that they needed to get around schools which aspired to bask in the reflected glow of university destinations for their students. This project leader reported that schools focused on what was best for them and looked good in the statistics (university enrolments) rather than what was best for individual students (Mike). These comments, taken together with STP project leader comments in the previous section, suggest there may be some mismatch between structural pressures on schools to demonstrate certain kinds of success and teacher efforts to support individual students.

However, one STP leader (Frank) did say they found the TEC's Ngā Kete secondary school student destinations information helpful for their STP project, and that it enabled principals and boards to look at where their students are actually going and how they are achieving at tertiary level. Several schools had told him that this data influenced their decision to engage more with the STP project.

Known from the outset and confirmed along the way

Interviewee comments, along with comments in steering group meetings during 2014 and 2015, indicate that these perception issues and their potential to derail the 500 goal were known early on. The issues were confirmed through Engineering e2e-commissioned research in October 2014 on the "perception

ecosystem" of parents, teachers and career advisors, employers, and school leavers and mature students and what they knew about engineering careers (Research First, 2014).

The report found that there was little understanding of contemporary engineering careers, that barriers to studying engineering occur early and compound throughout schooling, that students who do want to study engineering at tertiary level show a clear preference for doing so at a university, and that the New Zealand Diploma in Engineering and Bachelor of Engineering Technology pathways suffer low engagement because of their association with ITPs. It also pointed out that tertiary education providers are rewarded for putting their interests ahead of industry's needs.

Two other reports released in November and December 2014 lent further weight to the pathways perception issues. The first report provided background to a forum for providers of the NZDE and BEngTech. The forum purpose was to consider ways to increase the numbers of engineering technology students through more flexible programme entry for those not meeting programme entry prerequisites (Ako Aotearoa, 2014a).

The follow-up report on forum outcomes and also interviews with engineering students made a number of recommendations. Some recommendations focused on developing pathway *access*—for example, greater collaboration between engineering education providers and with their local secondary schools, and modular and bridging courses for secondary and tertiary students. Other recommendations focused on creating more pathway *demand*—for example, developing a collaborative, providers-industry-government "unified publicity campaign to increase learner demand … specifically targeted to under-represented groups" (Ako Aotearoa, 2014b).

Campaigning for visibility

Engineering e2e funded a marketing campaign, Make the World, designed to address the perception issues as part of its Public Awareness initiative. The campaign ran from January 2016 to June 2017 and sought to raise awareness and provide accurate information about the nature of engineering work, including the range of applications for engineering knowledge and skills. Indeed its approach was to "use a narrative that reframes the contribution of engineering" (Apera) in emotional terms: that engineering is a career option for expressing your passion and engineers are heroes who "make the world" as we know it.

It has been successful in terms of achieving more recognition of, and positive regard for, engineering as a career, particularly by females and Māori and Pacific peoples. However, a lack of understanding about the NZDE and BEngTech (known through other research and the 2010 NEEP report) continued. Perceptions of ITPs as providers remained negative. This was particularly marked for young people for whom tertiary education aspirations are not a given (e.g. Pacific peoples) and among employers (one interviewee reported that employers were not interested in joining a Make the World working group).

> We changed perceptions of professional engineering—that is was not just males in hard hats—and we changed perceptions of types of engineering—that it was not just bridges but electronics and design. [But] the more we focused on inspiration in relation to engineering, the less interested people were in ITPs. (Apera)

Several other interviewees suggested that Engineering e2e alone could not hope to resolve the esteem issues.

> I think it's an unconscious bias—lapsing into the university environment. There is independent research around perceptions of the sector and everything we found in Engineering e2e was that same stuff. (Ravi)

> When we started this out, the imperative was to find 500 graduates and it was clear from outset that an issue might be that graduates would be not aligned with what industry needs. Or that we might create more graduates but with no jobs to go to. (Donald)

> The steering group have been saying "you don't need a degree", yet none of them *haven't* got one. (Lance)

Since then, Engineering e2e has approved and funded an extension to Make the World with a view to better tackling these issues and maintaining the progress made. The steering group also noted that a group of ITPs have commissioned their own research into the barriers of studying at ITPs and discussed preliminary findings with the research team to determine if they might broaden the scope of the research to include engineering (steering group minutes, August 2017).

Longstanding perceptions about vocational education

The esteem issues arising are centred on how vocational education is defined and regarded. The NZDE, NZDEP, and BEngTech, and the ITPs which offer programmes leading to these qualifications, are all classed as "vocational" with an emphasis advertised as "hands-on" learning. Vocational education at secondary and tertiary levels is widely presumed to be technical, "hands-on", and/or closely identified with disengaged learners. The widely-held association between vocational education and less esteemed pathways and occupations is well established, dating from the organisation of earlier societies and industrial economies (Winch, 2013) and their conceptualisation in terms of dualisms such as mind/body and theory/practice (Dewey, 1916).

Vocational education in New Zealand is not mapped directly to specific TEOs as it is in other countries. However, it is closely associated with ITPs, PTEs, and ITOs, rather than universities and wānanga.[4] and it is associated with ITO-developed qualifications which are capped at level 6 on the New Zealand Qualifications Framework. These associations and perceptions of esteem have been questioned in some New Zealand research, which explores the way that vocation-specific education for professional occupations (e.g. in medicine) is not seen as vocational education, but "hands-on" education for other, technical fields is. What could be more hands-on than a GP whose work centres on touching their patients? (Vaughan, 2016).

Regardless of the logic, it remains a persistent issue in New Zealand because there is no recent history of strong links between education and labour markets. Rather than the institutionalised and highly-regarded apprenticeship systems of some parts of Europe and Japan, New Zealand's school leavers tend to go "job shopping" (Higgins, Vaughan, Phillips, & Dalziel, 2008). The "well-lit" pathway leads from school to university (Patterson, 2011), with universities having a longstanding influence over the secondary school curriculum and ideas about what is worth learning (see the "washback effect" in Hipkins, Johnston, & Sheehan, 2016).

The privileging of university pathways was further entrenched during the expansion of tertiary education in the 1990s: first, the introduction of EFTS-based funding instigated competition between education providers; secondly, a gap in apprenticeship provision opened up between the end of the traditional apprenticeship schemes and the emergence of ITOs (Murray, 2001). In terms of engineering, this situation may well have translated to a shift in where would-be engineers went for training (i.e. apprenticeships leading to New Zealand Certificate of Engineering ceased to exist and many more places in universities opened up).

There has been, therefore, a relative lack of understanding about vocational education knowledge and pedagogical traditions. A confusion between "career education" and "vocational education" (Watts, 2009)

4 New Zealand's 18 ITPs have close industry ties for their programmes which are mainly at certificate, diploma, and degree level (levels 3–7). The 11 ITOs are standards- and qualification-setting bodies for industry. Unlike other TEOs, they are not education providers, instead acting as brokers of training (including apprenticeships) which is largely delivered by employers.

adds to the sense that vocational ways of learning and vocational qualifications are second-best. That confusion has contributed to the ongoing inability of many schools to provide career education that is accurate, meaningful, effective and fit-for-purpose in terms of a 21st century context (Vaughan, 2011). The career education predicament particularly disadvantages school leavers who are not heading to university but who actually constitute more than 70% of school leavers (Ministry of Education, 2012).

For these reasons, there have been initiatives and marketing campaigns to raise the profile of vocational education in areas other than engineering (e.g. the Got a Trade, Got It Made campaign). These are likely to have generated greater awareness about specific pathways and occupations without necessarily addressing the persistent view that these meet the needs of the least able learners.

> It needs a cultural shift to value the vocational. The steering group cannot solve that problem. (Beth)

Employer perceptions and needs

A number of interviewees noted a strong employer resistance to the NZDE and BEngTech. Results of Engineering e2e employer surveys and interviews highlighted that many employers want BE(Hons) or 4-year degree engineers because it provides more flexibility around the scope of work (steering group minutes, September 2017). This is particularly the case for small-to-medium sized employers who lacked the capacity of large employers to have a range of engineering staff operating in different teams and at different levels.

> [Engineering e2e has] highlighted the very disparate views within industry about the qualifications. A small contract manufacturing mechanical engineering firm that may need access to professional engineers for certification of stuff but for 70% of their work, they need a technologist. But they go for a professional engineer because they need an element of that. (Ravi)

> When employers were given a choice between a graduate trained as technologist or a professional engineer, they would nine times out of ten opt for latter. So part of the project was to engage employers to make sure they think more laterally about employment practices so they don't have overqualified people. There's a difference between large employers and others. Large ones can accommodate a wider range of graduates because you can mix and match workforce and work coming up. Very small employers can't. They try to go for as wide a scope of practice as they can. (Donald)

Over the past 5 months, Engineering e2e has focused on producing more case study reports to explain credentials and their application to employers, and encourage uptake of those graduates (see, for example: Recruiting NZDE and BEng Graduates, December 2017; Geographical Testing Technician, October 2017; The NZDEP—A Next Logical Step, September 2017; Taking a Long-Term View to Recruitment, September 2017; Employing BEngTech Graduates, July 2017). It has also conducted a survey to find out more about the kinds of qualifications and skills needed by employers (steering group minutes, September 2017). It does this against the backdrop of falling enrolments in ITPs generally, not just in engineering.

This is where employer needs and preferences mesh well with those of students and their families and whānau. Employers look to secure the future of their business through as wide a scope as possible within one employee. Students and families and whānau look to secure their futures through immediate marketability of skills and longer-term career prospects. In this respect, employer perceptions and public perceptions of certain qualifications and education providers are fairly aligned.

Another related concern in producing the "wrong" kind of graduates relates to the sub-fields of engineering. Some parts of the industry face constraints on the kind of work they do (e.g. changes to, or contraction of, services). So these industry sub-fields may not look appealing or challenging enough, or may not be well known enough, to compete for the small pool of engineers who are coming through.

> [Without public service engineers] we will have more of the Havelock North types of crisis … I know there's a bigger pool of engineers coming through the system … But they're going into sectors that seem more interesting compared to local government. (Laurie)

> We've ended up thinking about what is commonly described as engineering. The education response to the NEEP report was framed in traditional domains—civil, mechanical, electrical. But what's happening in the technologist area are things like high technology manufacturing … it doesn't naturally fit the traditional domains … Framing it the way engineers have traditionally thought about themselves is not useful. (Donald)

Another interviewee explained how important it was for their area of engineering to have a clear pathway and sustainable recruitment and retention practices.

> Ours is the unknown engineering industry. When you look at career websites, you won't find us [my industry area]. We are also an ageing industry … Friends of friends, fathers-and-sons, mates of mates—that's how we get people. We are also getting people from overseas. (Shane)

These comments are important in the context of a New Zealand population that is ageing, shrinking, and increasingly ethnically diverse.

Headlines

- The goal of 500 engineering graduates has been achieved.
- Graduates were not the level 6 technicians and level 7 technologists most needed.
- A public awareness campaign raised awareness of what is engineering is, and the career options available.
- The campaign may also have inadvertently helped increase enrolments for the level 8 BE(Hons) through the university pathway, possibly at the expense of the ITP pathway.
- Employers, especially SMEs, favour BE(Hons) graduates because it provides the most bang for the buck in terms of scope of work within one role.
- Students' and employers' preferences are a good match in terms of career development and job structure, reflecting demand and not necessarily inaccurate perceptions.

SECTION FIVE

Reflections on past and future

This section draws on interviewees' comments about the way Engineering e2e was structured, its foundational goal, and stakeholder involvements. Some of these comments were reflections on things they thought unclear or unwise, and often made in response to questions about advice for the future. Interviewees were also asked about what barriers, if any, there might be to continuing a systems integration approach if Engineering e2e were no longer to exist.

Engineering e2e's goals

Several interviewees expressed uneasiness about the wisdom of the Engineering e2e goal of 500 more engineering graduates per year from 2017. For them, it started from a focus on credentials rather than a focus on employer needs, and they wanted to be driven more by demand-side, than supply-side, data and information.

> I'm not convinced yet with the research and data that would inform the decision-making. For example, if I look for stats on employer need or desires, I can't find it. If I want to go into a school and justify why people should do a BEngTech, it would be powerful to show that the engineering sector has strong demand for people ... but it seems almost anecdotal. (Chad)

> [We should have started] with the end point in mind ... we should have asked: what are the skills or constraints? Not start with: we are missing 500 credentials. [Eventually] I just gave up and stopped asking questions about employment destinations and roles. We needed to share the data with industry and identify choke points from employment perspective, not just focus on credentials. (Beth)

> We needed a strong understanding of the [real] problem from the start. (Apera)

> Make sure you are clear on the extent of challenges for the sector, as well as the benefits. Then you can guarantee support, not just tell a story. (Laurie)

> Make sure there's a real need for jobs in that sector. We don't want to create hype without that. (Mike)

The original 2010 NEEP report had involved the perspectives of industry groups and employers, not just education or credentialling bodies. However, it seems that some interviewees felt the a credentials target had come to drive Engineering e2e at the expense of employers. In other words, there seemed to be more attention going to the supply side of things than the demand side.

This is perhaps understandable given that Engineering e2e is managed by the TEC and that most initiatives focus on the tertiary education part of "the engineering pipeline" (the four parts being: primary schooling; secondary schooling; tertiary education; employers). However, several interviewees expressed frustration over the way that education interests seemed to dominate:

> The contributions from the academic community were full of acronyms and jargon and it was a barrier. (Bo)

> [Engineering e2e] seems quite academic and theoretical. Engage this consultant and get that research, and write reports on findings. [Why don't we] talk to students and institutes and employers and glue the whole thing together? I feel the project is busy doing too much of the wrong thing. (Josh)

> The TEC only focused on the bits it has control over—tertiary education. (Beth)

Two interviewees explained how important it was to ensure employers or employer representatives on the steering group were welcomed and heard.

> [If designing something like Engineering e2e,] bring in someone with technical experience in the industry and train them up on administering a programme instead of bringing in a Ministry person and educating them about the sector ... Make it sector-led because people want to fix their own problems. (Laurie)

> The reason for Engineering e2e is valid. But we should have thought about different ways to achieve that 500 goal. We needed more clarity about strategies. I'd have liked more influence on the steering group as an employer representative. There was a lack of ability for us [employer representatives] to steer. (Josh)

Stakeholder involvement

Several interviewees also reflected on the stakeholders involved in Engineering e2e and the difficulties in getting it right.

> You need a balance between institutions, government, employers and peak bodies like BusinessNZ and IPENZ. You can't just deal with government. It took about a year to figure out who the stakeholders were and who really mattered. (Lance)

> Make sure the industry stakeholders or representatives are reflective of the diversity of the industry because there is no one voice of industry. There are different business sizes and different types of engineering. (Ravi)

One interviewee felt that ITOs should have been included in the steering group, especially with the Sponsored Degrees initiative (also known as Degree Apprenticeships) (Beth). The steering group has only had one ITO representative (Competenz) which joined in mid-2016 (it is no longer a member, but Primary ITO is). NZBED is the standard-setting body for NZDE and NZDEP and has been a steering group since 2014. However, ITOs are the standard-setting bodies for a number of other level 6 Engineering qualifications, e.g. ServiceIQ's New Zealand Diploma in Aeronautical Engineering (Technical Support); MITO's New Zealand Certificate in Mine Surveying; and Connexis' New Zealand Diploma in Electricity Supply.

Some interviewees wondered whether there should or could have been representation from the compulsory schooling sector or an inclusion of schooling as part of the wider system (i.e. not just through the STP projects).

> It would have been good to have the Ministry of Education in the steering group. (Ravi)

> We looked at the problem as being a problem of getting engineers into engineering education. We didn't look at the system. We didn't fully understand the nature of the high school system. (Frank)

There has never been any representation at steering group level from the compulsory schooling sector (e.g. the Ministry of Education) or from peak bodies for teachers and principals (e.g. the Post-Primary Teachers' Association or Secondary Principals' Association of New Zealand). There are also no career development professional bodies such as Career Development Association of New Zealand (CDANZ) or the school-based Careers and Transition Educators (CATE) in the steering group. This is interesting in light of Engineering e2e's promotion of careers and pathways in engineering.

Recommendations from the original NEEP report in 2010 make references to the importance of the compulsory schooling sector in the overall system, including that pipeline "leakage" occurs there. Steering group minutes over the past 3 years also refer to the importance of compulsory schooling, including that career decisions seem to occur fairly early on in this phase. Primary school and secondary school represent two of the four chunks in the Engineering Pipeline diagram (shown in SectionTwo). The six STP projects rely on collaboration with schools.

Exactly what involving the compulsory schooling sector would look like is not immediately obvious. Schools do not have a mandate to try and increase the number of engineers. However, schools do have a mandate to provide career education (see National Administration Guideline 1f) but promoting one specific career over others and prioritising preparation for work is not their role.[5] However, several interviewees did suggest there was some potential for schools to work with Engineering e2e in a way that keeps open engineering possibilities for students.

> I'm not sure we are changing things. [Students] that will do well would have [taken engineering anyway]. I'm not sure we're changing people at level 2 and 3. Often the die is reasonably well set by time of level 1 at high school. Trying to effect inspirational change at that [later] stage is quite difficult. This idea that we can give people an amazing experience at level 2 won't convert them … we need to focus on earlier years. (Chad)

> [We should have had some] focus on schools and dealing with where other industries might compete for the same pool of people. We could consider targeting maths and science teachers and developing curriculum content. (Beth)

> [We have] lots of little groups trying to do things—the IT sector, engineering—there is no cohesion. What holds all these initiatives together? When you talk to schools, they see you as yet another group. If the Ministry of Education could promote this in a cohesive way as STEM or STEAM, it would be good. (Frank)

It is not obvious whether schools really much need *from* Engineering e2e, though some schools might welcome this, as those involved with STP projects have. However, there is potential for Engineering e2e to "translate" some of what is learned from some of the initiatives back to schools for the purposes of sharing information and learning. For example, the Micro-credentials initiative engages with ideas and issues that may be of interest to schools, such as credentialling being driven by the learner and how to focus on "bite-sized" learning without losing a sense of the big picture.

It might also be useful for Engineering e2e to involve someone from the Ministry of Education's Graduate Achievement, Vocations and Careers Group, which is responsible for tertiary education strategy, policy, sector performance analysis, youth guarantee and vocational pathways. Given that Engineering e2e is located against a backdrop of competition between tertiary education providers, there might also be potential to draw on the Ministry of Education's experience in trying to shift from a model of schooling that has created competition to development of a collaborative Communities of Learning model.

5 The New Zealand Curriculum's aim is to support young people to become confident, connected, and actively involved lifelong learners (Ministry of Education, 2007).

Sustainability of systems integration

Do we think about Engineering e2e in terms of the sustainability or embeddedness of any new collaborations and structures emerging? Or do we think in terms of an understanding that a systems integrator is necessary in some ongoing way?

Interviewees were asked about ongoing systems integration activity without Engineering e2e. All interviewees felt that the role of systems integrator was an important one. In general interviewees did not seem confident that systems integration could work without there being an entity acting as the designated integrator. Their responses about that role differed depending on whether they focused on the immediate priority of engineering or on the bigger picture of systems integration as a general aim and way of working.

Several interviewees acknowledged that collaborations might endure and produce change in what is regarded as business-as-usual. However, they were cautious in their optimism, noting the system itself did not necessarily facilitate this. Their views resonate with the Productivity Commission's findings in their review of tertiary education that the funding system militates against collaboration and innovation (New Zealand Productivity Commission, 2017).

> Without other changes in the system, you need to still have an integrating body. Who else will do it? It will not magically happen. If it stops, I would be disappointed if we lost ground on collaborations, programmes content improvement. (Beth)
>
> Engineering e2e introduced us to each other—that's what it felt like … So would everyone revert to type? I'd hope not. In this area, you would say a successful project would be one where the ongoing engagement was embedded. We just commissioned work on what work-ready engineering graduate would look like. You'd expect that to be picked up and reflected in curriculum development for providers … You hope that, beyond the addressing the particular thing, there is some spill-over. (Donald)

Some interviewees focused on systems integration for *engineering* (rather than systems integration as an aim and way of working in general). They could not see any other group besides Engineering e2e working in this way for engineering. Two interviewees felt that ENZ would not play an integrator role because it was too invested in professional engineers and the BE(Hons), rather than the full range of engineers and the NZDE, NZDEP, and BEngTech (Bo; Josh).

One interviewee thought integration would be very difficult without a dedicated team, project leader, and programme coordinator (Mona). Two others were also hesitant about whether there were other systems integrator options.

> I don't think anyone else would pick it up and run with it. ITPs are a business and think about bums on seats. They will focus on courses that are popular and generate revenue. They won't promote or encourage engineering programmes if they are not making money. (Josh)
>
> It would come down to requiring collective impact action. The best option is clusters—providers and industry and schools work together. Over time, you gain a slow change in outcomes. If you can't do it nationally, you'd have to do locally. It still takes resources and focus. (Ravi)

The STP project leaders raised the prospect of a loss of Engineering e2e funding. They saw this as a barrier for their collaborative work with schools. This is interesting in light of the existing measures to encourage schools and tertiary education providers to work together. Not all of these provide funding but they do encourage the formation of pathways and alignments—though not specifically about engineering. These existing measures include: the Secondary–Tertiary Alignment Resource; Youth Guarantee; Vocational Pathways; and Gateway.

> We can do things with schools for free because of Engineering e2e … There are schools and ITPs who do a great job of secondary–tertiary partnerships [not related to Engineering e2e] but it relies on investment from principals and senior leaders. So if you don't have that, it'll just die in schools. (Michelle)
>
> I am trying to set up systems that will continue after the project finishes. We're not delivering things to get people interested; we're trying to change school culture. I don't think there will be significant change until we have an integrated STEM approach. We are nibbling at edges of culture until then. As soon as champions leave or retire, the momentum will diminish. (Frank)
>
> My job would not be there [without Engineering e2e] funding. The polytech would have to fund it. I'm sure they would see the value. They might put my role into the marketing department but marketing is very generic and I see it as a strength not to be in marketing. I can just focus on engineering. (Mike)

Three other (non-STP) project leaders thought their work could, and would, continue without Engineering e2e; it would just be more difficult. Their position probably reflects the fact that at least some of their work had begun prior to Engineering e2e support or involvement. They were clear that Engineering e2e's support had been valuable and allowed them to do more work, or have greater reach with it. However, their work was not necessarily new and dependent on Engineering e2e in the way that STP leaders suggested theirs might be.

> [My project] could stand on its own. It advocates for young people rather than for the industry. Engineering e2e just aggregates all the industry information. But we probably couldn't have done that part without Engineering e2e taking that systems view. (Apera)
>
> We [my industry group] are applying to TEC for funding but support of Engineering e2e should make it easy. We still have to tick all the boxes but Ee2e have arranged things like presenting so that's good for us. It would have been a barrier without them. We were going to fund the first project ourselves but it would be a one-off because there would be no more money. But if we get funding, we can roll it out … and use that money to promote the whole thing instead. (Shane)
>
> Engineering e2e gives us [in my industry area] momentum and credibility, and financial backing too. But most of the value is in access to knowledge and people. (Laurie)

Headlines

- All interviewees thought the role of a systems integrator was important.
- Some interviewees thought Engineering e2e was driven by a focus on credentials target at the expense of other considerations.
- Some interviewees questioned the mix of stakeholders and forms of engagement or interaction with them—for example, the lack of representation from the compulsory schooling sector.
- Most interviewees were not confident that systems integration would happen without a designated entity acting as an integrator. There were some differences in how they saw this depending on whether they were thinking of benefits to engineering specifically or alignment within the broader system generally.
- STP project leaders thought that creating or maintaining pathways between schools and tertiary education providers needed specific resource or funding.

SECTION SIX

Concluding remarks

A numerical goal

Engineering e2e started on the basis of a current—and anticipated future—shortage of engineers and the dangers of not addressing this in terms of New Zealand's economy. As well as explanatory terms, the shortage was expressed in numerical terms in the NEEP report (2010). It argued for more engineers overall, and especially for engineering technicians and technologists, respectively requiring qualification at level 6 (NZDE) and level 7 (BEngTech) on the New Zealand Qualifications Framework.

The Government set the goal of 500 more engineering graduates a year from 2017 onwards and Engineering e2e took up this mission. That goal of 500 more engineering graduates has been achieved, with the TEC confirming 511 engineering graduates from courses in 2016. However, the underlying goal of more technicians and technologists, who do and will play a particular role in the economy, has *not* been achieved. Over the past 3 years, the numerical focus has been useful for galvanising support. It has also initially masked, and then revealed, other issues—some of which are deep-seated in New Zealand and beyond the control of Engineering e2e.

The role of a systems integrator

Engineering e2e took on a very ambitious agenda in trying to be a "systems integrator". It attempted to "catalyse, coordinate, and monitor" activities throughout the education-to-employment system. There is no blueprint for exactly what systems integration involves and it can be, and has been, interpreted differently by different entities.

The former Careers New Zealand (now part of the TEC) has had a systems integration role in New Zealand. However, Engineering e2e's approach sets it apart from that of Careers New Zealand. Engineering e2e has had a *workforce development* perspective on systems integration, coordinating individual opportunities, organisational goals, and national priorities for economic growth. This enabled it to enlist the support of engineering-invested stakeholders, and connect very directly to their needs.

Careers New Zealand, on the other hand, has had a *career development* perspective on systems integration. Along with its independent status, this perspective has enabled it be an all-age, all-stage, and pan-careers information and support service. Its immediate beneficiaries are individuals and families and whānau, who are supported to manage their careers (and ongoing learning) throughout life. This is strategically important to public policy. Engineering e2e has an even more direct relationship to public and economic policy.

Catalysation, coordination, and monitoring

Engineering e2e's three work streams (Marketing and Promotion; Educational Delivery; Industry Partnerships) were given effect through 12 distinct initiatives (see Section Two for a list). Some of these initiatives, such as Secondary–Tertiary Pathways, contain multiple projects and partnerships. The website hosts the initiative work plans, and their goals and success indicators. Reports from all the initiatives are also available on the website. The most recent Newsletter (No. 38, December 2017) lists achievements to date across all the initiatives.

Thinking about the activities of the Engineering e2e entity overall, within the initiatives and steering group, there is evidence from reporting and from interviewee comments that Engineering e2e has acted as a systems integrator. The following table lists examples, which are classed as examples of catalysation, coordination, or monitoring—though in reality there is also plenty of overlap and connection between these.

TABLE 4 **Examples of Engineering e2e's systems integration activities**

Activity	Examples
Catalysation	Taking a systems view disrupts the accepted idea of competition between providers
	Establishment and oversight of new relationships, leading to opportunity-spotting
	Opening up of "space" through funding and resource for project leaders to work differently and consider possibilities
	Operation outside of business-as-usual sparks possibility in steering group members and stakeholders
	Influential leadership lends weight and creates momentum
	New things tried in curriculum, pedagogy, and pathways in secondary and tertiary education
	Field-specificity attracts stakeholders and sharpens focus
	Raised awareness of engineering careers in general, and specific sub-fields of engineering
	Creation of possibility for changes to credential design
Coordination	Direction and funding to initiatives and projects
	Liaison and interaction with stakeholders: tertiary educators, employers, professional groups and peak bodies, and government agencies
	Oversight of, and guidance for, partnership projects that enable changes to curriculum, pedagogy, pathways
	Oversight of new pathways to provide clarity and flexibility to stakeholders
	Cross-organisation groupings create new or deeper understandings, and some new alignment possibilities
	Steering group leverages networks
Monitoring	More understanding of the implications of data among project leaders and steering group members
	Development of new communication channels that pull together, and clarify, information from multiple sources and stakeholders, for multiple stakeholders

The pipeline and the system

Although compulsory schooling comprises half the "engineering pipeline", in practice that first "e" in e2e (education-to-employment) has mainly focused on tertiary education. That is, most of the initiatives addressed tertiary education design and provision (Secondary–Tertiary Pathways projects are an exception, though all are led by TEIs).

This focus is understandable given that engineering does have significant health and safety aspects to occupational competence and require assurance through tertiary level credentials. The tertiary education focus is also understandable given that Engineering e2e is managed by an agency (the TEC) which funds and monitors the performance of TEOs.

A pipeline perspective highlighting tertiary education is also useful for its capacity to create an easily identifiable goal and momentum towards it. The downside of this perspective is its tendency to cast pathways in linear terms and to over-simplify matters. There can be lots of activity but it is much harder to achieve meaningful alignment between different sets of stakeholders. This is because some stakeholders (e.g. families and whānau) who would feature strongly in a lifelong and lifewide systems view, do not feature so much in a pipeline view. Interviewees highlighted the lack of involvement from the compulsory schooling sector and a focus that kept tertiary education in the foreground, and employers and schools more in the background.

Shifting attention to retention and development

From the beginning there has been an assumption that the expressed need for more engineers (of any kind, at any level) can be met by having more people train and qualify as engineers. As with other occupations such as teaching, it is possible to have pipeline leakage occur soon after qualification or employment. It may now be worth Engineering e2e turning some of its attention to the retention and professional development of qualified engineers. Although career management has not been a focus so far, there is potential for it within Engineering e2e's existing initiatives. This could be linked up with the existing work on engineering capabilities started through the Growing the Pipeline initiative.

Re-thinking engineers and engineering

Engineering e2e is competing with other industry areas for a pool of school leavers that has been reducing for the past 5 years. This suggests that the one initiative that did not get going over the past 3 years—Growing Through Diversity—might arguably be an especially important one. This is because it is offers potential to recruit and develop people who are not the same as the current crop of engineers.

The Secondary–Tertiary Pathways projects have made some inroads here as they have been charged with increasing the interest—and enrolment—of women, Māori, and Pasifika. We know from research into engineering technicians that the nature of the work now requires more than technical skill. It requires a "social eye" sensitive to communities, and cultivation through authentic work practice (Vaughan, 2017). A more diverse group of people entering engineering, with more attention to an educative role for employers, might fit well and add great value to the industry.

Supply and demand against a background of esteem issues

Trying to achieve labour market alignment is always fraught because of the different kinds of *demand* involved. Engineering e2e started with a focus on job market alignment (matching the number of graduates to current or future demand). However, it soon became apparent that there was an

interconnected issue of skills alignment (matching capabilities and qualifications to what is most in demand in the labour market).

The 2010 NEEP report argued for, and quantified, a need for engineering technicians and technologists. This seemed to constitute "demand". However, there were different kinds of demand in play. The public, students, and families/whānau demanded career development opportunities and high-esteem pathways and qualifications, i.e. degrees and university over diplomas and ITPs for marketability and long-term options. Some employers, particularly SMEs, favoured professional engineers over technicians and technologists because of the nature of their business, job structures, and scope of work.

The long-standing perceptions about vocational education as second best, and the dominance of SMEs in New Zealand, are not situations of Engineering e2e's making. New Zealand has no recent history of strong links between education and labour markets. School leavers must find their own way, and employers must somehow find them for their businesses. University pathways have had a particularly privileged status since the reforms of the 1990s (see Section Four). So while vocational education in New Zealand is not mapped directly to specific TEOs, it is closely associated with ITPs, PTEs, and ITOs. Thus qualifications developed by, or available through, those TEOs (such as the NZDE, NZDEP, and BEngTech) are held in lower regard than qualifications offered by universities (such as the BE(Hons)).

This situation has made Engineering e2e's task very difficult, and it explains why the major marketing campaign did not make all the ground it was expected to make. While Engineering e2e considered a system from a workforce development perspective, some of the many stakeholders within it naturally considered their own best interests. Individuals and families of course focus on career prospects and career development. Employers of course focus on business survival. The perspectives of both groups (individual/families and employers) were reasonably aligned in terms of privileging the BE(Hons) as providing the greatest benefits for their own investments.

Engineering e2e change and sustainability

Engineering e2e had an unusual structure in being a partnership across education and employment sectors, with a collaborative approach to its work, but managed by one government agency. In many ways, it operated "below the radar" and so did some project leaders who had to negotiate the boundaries and accountabilities of their own institutions and organisations in carrying out their Engineering e2e work. The downside of such a structure and approach is that things remain as they were, particularly if Engineering e2e ceases to exist. The positive aspect of this is Engineering e2e's capacity to sidestep the constraints of being business-as-usual for any one agency or organisation.

This does mean the system might remain largely as it is. Especially because current TEO settings, which are outside the control of Engineering e2e, discourage education providers from collaborating or innovating (see the Productivity Commission's 2017 work on tertiary education models).

However, Engineering e2e seems to have oriented some individuals and organisations to a line of sight beyond their immediate concerns or harnessed their immediate concerns (e.g. recruitment) in support of a bigger goal for the country. This might suggest that there should always be a systems integrator, counteracting self-interest and the incentives and constraints of current settings. Engineering e2e has certainly created some positive working relationships and collaborations. The challenge for sustaining the work may be in dealing with conflicting measures between the different stakeholders and organisations involved, and how to continue the work if and when personnel changes occur.

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