Royal Society Te Apārangi

Expert Advisory Panel

Technology and hangarau learning in Aotearoa New Zealand

Advice on improving teaching, learning and assessment within NCEA and the secondary–tertiary education system to support career pathways

Hōngongoi July 2021

ROYAL SOCIETY TE APĀRANGI

Whakarāpopoto

Executive Summary

An Expert Advisory Panel was set up in December 2020, under the auspices of Royal Society Te Apārangi, to provide an independent source of expertise to the Ministry of Education on improving teaching, learning and assessment in the Technology learning area.

The Panel met a number of times and through its deliberations reached consensus on a number of findings.

Aotearoa New Zealand has a world-leading curriculum in the Technology learning area. There are clear benefits to all students of successful study in the learning area. The two big ideas – technological literacy as an enabler for people to live a dignified and successful life in the face of ever-changing technology, and multi-disciplinary, purposeful, innovative knowledge-rich practice – continue to be as relevant to the needs and aspirations of this country as they were 30 years ago. Broad-based 'Technology education for all' is aligned to the goals of this country to be a nation of world-leading innovators.

Research evidence shows that the potential benefits of the curriculum have been realised when teachers have had sufficient professional development and support. In the more recent absence of that support, there has been a discernible drift back to technical education, with this being inadvertently supported by an overly permissive NCEA assessment matrix that allowed students to obtain 14 credits without really achieving proficiency aligned to the big ideas of the curriculum.

In effect, by a series of incremental changes, largely in response to the petitions of lobby groups, the totality of the curriculum and the senior school assessment in the Technology learning area gradually lost its coherence around the big ideas and the three fundamental strands of the curriculum at the core of the Technology learning area.

Learning for all students in this country will be enriched if it draws as much on Mātauranga Māori as on knowledge derived from 'western' science, and on methods from kaupapa Māori, such as rangahau, as well as from the technological practices framed in the western world. Technology in this country needs to be firmly embedded in the cultural and social contexts of the nation fully implementing the key principles of Te Tiriti o Waitangi. Although relatively few in number, students studying hangarau need as much consideration as other technology students.

The opportunity to re-develop the assessment matrix in Technology provides the Ministry with a unique opportunity to re-align what students study in senior high school to conform with the Technology curriculum. The educational benefits are so great that the Panel considers this must be done. This requires pedagogy and assessment to be strongly linked back to the foundations of the curriculum. The panel recognises that an abrupt step-change may be too great for some teachers. Rather than compromise the long-term assessment matrix, it would be better to support teachers and schools through a transitional period with suitable professional development.

Although well-intended, opportunities for specialisation and attempts to promote pathways have proven counter-productive – at worst, restricting rather than enabling the learning journeys of some students. Students who succeed in any technology programme obtain benefits. Pathways are limited – there is one from design-rich technology study to tertiary study in the same field, and students studying digital technology at school are likely to progress to either engineering or information technology tertiary study. Students taking unit standards-based programmes at school are likely to progress to non-degree tertiary study, especially in engineering-rich domains.

The long-term benefits of students studying Technology will be best realised by a 'thin-walled' rather than 'thick-walled' approach to subjects, encouraging cross-linking and multi-disciplinary approaches. In this context, the Panel recommends minimising the number of subjects in the learning area to no more than three at each of Levels 1, 2 and 3, continuing to emphasise a broad-based technology literacy, and a focus on innovative technological practice to meet needs, address issues or take advantage of opportunities.

The proposed explanatory by-lines for the three subjects should be widely used:

- **Digital Technology**: applying computational thinking and creating digital outcomes.
- **Design in Technology:** exploring feasible spatial and product designs by modelling and drawing.
- **Development in Technology**: making fit-for-purpose products, artefacts, devices or outcomes.

In each of the three subjects, the achievement standards must cover the Nature of Technology, broad-based conceptual and procedural Technological Knowledge and Technological Practice.

To avoid perpetuation of the highly undesirable two stream system in schools – academic and vocational – it would be desirable to discontinue the two awards (university entrance and the proposed vocational entrance) that end up being signposts to pre-determined tertiary destinations. Tertiary providers are well able to assess whether a student's prior achievement gives them a reasonable chance of success in a particular tertiary programme.

To support students whose educational needs are best met by a combined secondary/tertiary programme of learning, a coherent work programme is needed between the Workforce Development Councils and the Ministry to co-create a small number of relatively standardised 'subjects' (for schools to deliver) that contain content the Councils see as supportive of student progression towards Levels 3–5 qualifications. This would sit beside the opportunity for other school students to undertake some university study.

Rārangi Upoko

Table of Contents

Wāhanga Tuatahi

1. Introduction

In December 2020, the Ministry of Education approached Royal Society Te Apārangi with a request to provide independent advice on improving teaching, learning and assessment in the Technology learning area.

As part of the NCEA Change Programme and the Review of Achievement Standards, the Ministry has an important opportunity to improve the teaching, learning and assessment of Technology within NCEA, and to ensure that pathways into tertiary study and careers for students are signalled and supported more effectively.

1.1 Terms of Reference

The terms of reference of the Panel were to provide advice and feedback on the work within the Ministry's Secondary Tertiary team relating to Technology within NCEA and the secondary–tertiary education system. Specifically, this will relate to:

- the relationship between NCEA, the New Zealand Curriculum, Te Marautanga o Aotearoa and industry-derived Technology and Hangarau learning, noting that the immediate focus is on Technology in the New Zealand Curriculum
- how the senior secondary system can effectively support Technology and Hangarau pathways at NCEA and into further study and employment
- the Review of Achievement Standards and development of subjects at NCEA Levels 2 and 3 (including New Zealand Scholarship).

The key output of the Panel was intended to be a report providing advice on how Technology and Hangarau pathways can be improved through NCEA and the secondary education system, especially at NCEA Levels 2 and 3. The scope of this advice was intended to be limited to the responsibilities of the Ministry's Secondary Tertiary team, although other relevant aspects of the education system could be considered or referenced.

The Panel was asked to consider the relationships between Technology, Digital Technology, Hangarau and Hangarau Matihiko, including considering how students and ākonga across English and Māori medium access this learning.

1.2 Panel Composition and Work Programme

Members of the Panel (short biographies can be found in Appendix 1):

Professor Alister Jones (chair) (University of Waikato)
Dr Andrew Cleland FRSNZ (Royal Society Te Apārangi)
Angela Christie (United Fire Brigades Association)
Astrid Visser (Massey University)
Dr Cathy Buntting (University of Waikato) (special contributor)
Cheryl Pym (University of Otago)
Dr Cliff Harwood (NZ Defence Force)
Kane Milne (Te Wānanga o Aotearoa)
Mary-Claire Proctor (Wellington Institute of Technology and Whitireia Community Polytechnic)
Thomas Mitai (Te Whare Wānanga Awanuiarangi)

The Panel met on a number of occasions by Zoom in late 2020 and early 2021, and then face to face on 30 April 2021, at which meeting it formulated its findings. Subsequent Zoom and email interactions were used to finalise the report.

In section 2, and also in later sections where the Panel has found it necessary to use or present information that is not from peer-reviewed literature, is from a source that is no longer publicly available, or is drawn from the personal records of participants in the activities being described, it has taken reasonable steps to ensure the accuracy of that information.

The report has been externally reviewed by Dr Kerry Lee (University of Auckland), Professor John Williams (Curtin University) and Professor Marc de Vries (Delft University of Technology).

1.3 Outline of the Report

This report begins by outlining key events in the development of Technology Education in New Zealand. This history is important: New Zealand has a world-leading Technology curriculum, iteratively developed through close interactions between policy, research and practice. As Marc de Vries commented in meetings with the Ministry in 2008:

> For the future of technology education, it is extremely important that a research and development culture is maintained that supports the learning area … This is currently the case in New Zealand and for that reason the rest of the world's 'technology education eyes' are now on New Zealand. In New Zealand there is a unique opportunity to set an example internationally of how to develop a sustainable learning area that in the course of time will prove to have measurable benefits.[1]

While the Panel is cognisant of the Ministry's current Curriculum Refresh project, our report is premised on the assumption that the two big ideas (technological literacy, innovation), and three strands (nature of technology, technological knowledge, technological practice) of the current curriculum for the Technology learning area remain fit for purpose.

Building from this discussion of the development of Technology education and its curriculum emphases (Section 2), the current achievement standards available for Technology are listed and NZQA data are presented that show student engagement with the standards for 2014–2018 (Section 3). The discussion then turns in Section 4 to secondary–tertiary pathways. These are defined as identifiable pathways taken by a significant number of students; that is, large cohorts of students have taken substantially equivalent components within their school learning programmes and choose equivalent next steps in relation to tertiary study. Data demonstrate that relatively few such pathways exist.

Section 5 touches briefly on the relevance and value of generic technological literacy for employment across a wide range of career options, and the need for on-the-job training in many careers. Section 6 provides a summary of the emerging findings and the underpinning evidence. Section 7 uses the preceding discussion to consider the proposed NCEA reforms, proposing that if there are to be three subjects, a curriculum-true and educationally sound set of three subjects, reasonably well-matched to student interests, can be described as follows:

[1] Ferguson, D. (2009). *Development of technology education in New Zealand schools: 1985–2008*. Wellington, NZ: Ministry of Education. http://technology.tki.org.nz/Teacher-education/Archived-papers/Development-of-technology-education-in-NZ-1985-2008

Digital Technology: Applying computational thinking and creating digital outcomes.
Design in Technology: Exploring feasible spatial and product designs by modelling and drawing.
Development in Technology: Making fit-for-purpose products, artefacts, devices or outcomes.

The Panel also proposes explanatory 'by-lines' to inform parents and students about the purpose of the subject, and short descriptions to support teachers' understanding. Recommendations are also outlined for developments at Levels 2 and 3. These link back to earlier arguments made through the report about the ongoing relevance of the Technology curriculum, and the data presented in relation to achievement standards use and secondary–tertiary pathways.

Implications for the Technology teaching workforce are also briefly considered in Section 7 – change will only be effectively implemented if the current and future Technology teaching workforce is supported and developed.

Section 8 summarises the key findings and recommendations of the Panel.

Wāhanga Tuarua

2. Developing Technology Education in Aotearoa New Zealand

The curriculum is never a neutral assemblage of knowledge, somehow appearing in the texts and classrooms of a nation. It is part of a selective tradition, someone's selection, some group's vision of legitimate knowledge. It is produced out of the cultural, political, and economic conflicts, tensions, and compromises that organize and disorganize a people.[2]

2.1 Early Technical Education

The development of technology and the handing down of the associated 'know-how' has been a characteristic of every society. In Aotearoa New Zealand two technological systems met in 1769. Ancestors of Māori had voyaged across half the world at a time when Europeans had yet to venture beyond the Mediterranean or their littoral waters.[3] Technological knowledge and innovative culture were evident among Māori, as tangata whenua, with unique building, clothing, food preservation, farming and health practices, among others. Māori technology development continued after European settlement.[4] For example, the engineering know-how by which Ruapekapeka Pā was constructed in 1845 so impressed the British military that plans were prepared and sent back to England so the British Army could learn from them.

England had long had a series of guilds that had fostered and handed down technical know-how to new generations. Colonial settlers from the United Kingdom and elsewhere brought such technical

[2] Apple, M. (1993). The politics of official knowledge: Does a national curriculum make sense? *Discourse: Studies in the Cultural Politics of Education*, 14(1), 1–16.

[3] King, M. (2003). *The Penguin history of New Zealand.* Auckland, NZ: Penguin.

[4] Durie, A. (1997). Technology and Māori. In J. Burns (Ed.), *Technology in the New Zealand Curriculum: Perspectives in Practice* (pp. 31-45). Palmerston North, NZ: Dunmore.

knowledge, informed by the technology development occurring in the United Kingdom, Europe and the Americas during the industrial revolution. Until an education system could be established in Aotearoa New Zealand, technical knowledge was informally transferred and handed down.

In 1796, a significant development occurred in Scotland that would have an impact on technology education in Aotearoa New Zealand (although not until the 1960s.) Founded under the will of John Anderson (1726–1796), Professor of Natural Philosophy in the University of Glasgow, Anderson's College (also known as the Andersonian Institution) was established in 1796. In keeping with John Anderson's views, classes were offered for the mechanics of the city. Over time, a distinct Scottish technology education system developed from this base, with a significant level of coherence between school and tertiary sectors.

Early schools in Aotearoa New Zealand were primarily missionary-led.[5] The first technical education probably commenced with the introduction by central government of the Native Schools Act in 1867. This marked the beginning of two educational milestones: first, the beginning of a national education system for Māori (before one for the British settlers' children, which was still run at the provincial level) and, second, the policy of using English as the sole medium of instruction. In line with the prejudice of the day, other than arithmetic and learning to read and write the English language, instruction was largely on technical and domestic skills – what was deemed suitable for Māori by the authorities of the day.

Compulsory primary education was introduced in 1877, although for Māori this was delayed until 1894. Commencing in the late 1860s with the establishment of the first high schools, secondary education was on a user-pays basis, although some scholarships were available. The first technical schools initially offered only evening classes so tradespeople could attend after work. In 1900 the Manual and Technical Instruction Act was passed, and secondary schools had to incorporate technical subjects.[6] In 1903 students who had passed a proficiency examination were allowed free secondary education, and the technical schools started to offer day classes so students could enrol for technical education post-primary school. This was a common route for children from working class families. It reinforced a divide between academic and non-academic pathways – a historical legacy that continues today.

In 1936 the proficiency examination was removed,[7] and by the end of World War II the school leaving age was raised to 15. In the 1960s the distinctions between technical and other high schools started to disappear. Nevertheless, teacher-driven methods of instruction persisted in which children followed pre-determined work plans developed by teachers to impart the desired manual dexterities and competencies. Over time, technical schools were split into what were to become the local technical institutes (polytechnics) and secondary schools. The last native schools were phased out. To the extent that technical education occurred it was now in secondary schools and followed a narrow pedagogical practice. There was little opportunity for students to be creative, or to be involved in decision making in regard to what they were to undertake.

[5] Swarbrick, N. (n.d.). *Primary and secondary education – Education from 1840 to 1918*. https://teara.govt.nz/en/primary-and-secondary-education/page-2

[6] Jones, A., & Compton, V. (2009). Reviewing the field of technology education in New Zealand. In A. T. Jones & M. J. de Vries (Eds.), *International handbook of research and development in technology education* (pp. 93–104). Rotterdam, Netherlands: Sense.

[7] Swarbrick, N. (n.d.). *Primary and secondary education – Education from 1840 to 1918*. https://teara.govt.nz/en/primary-and-secondary-education/page-2

By the 1970s, technical education was occurring in both senior primary school (or intermediates where these existed) and in high schools. Gender stereotyping was still dominant – generally boys studied woodwork and sometimes metalwork, and girls studied cooking, sewing (more latterly home economics) and sometimes typing. Technical drawing was also becoming available (later to be known as graphics and design). More academic students were often able to bypass these types of learning in high school. The persistence of technical subjects was more the result of the Manual and Technical Instruction Act,[8] plus the trades ethos and education for domestic roles of the early technical and native schools, than a specific selection of relevant technical subjects for the 1970s and beyond.

Whereas the polytechnics were providing increasing amounts of technical education, technology as an academic discipline was introduced into the university system in 1961 by Massey University, with a four-year Bachelor of Food Technology. By the 1970s this had become a Bachelor of Technology available across a range of industry-oriented disciplines. Two early professors at Massey had studied at a Scottish tertiary institution descended from Anderson's College in Glasgow, bringing the ethos of the Scottish technology education system with them; this ethos became the basis for degree-level technology education in this country. Thus, technology as a degree was akin to an engineering degree, and to enter it students had to have succeeded in academic mathematics and science subjects. It did not progress from the technical education in schools. The University of Waikato followed with a Bachelor of Science and Technology, the University of Otago with a Bachelor of Applied Science, and the University of Auckland with a Technology degree. However, these offerings occurred independently of the development of technical education in schools.

Despite 'design' being incorporated into the teaching of technical subjects with the introduction of the Form 1–4 (years 7–10) Workshop Craft curriculum in 1975[9] and the Form 5 (Year 11) Workshop Technology curriculum in 1977,[10] by 1985 educators in Aotearoa New Zealand questioned the continuance of the narrow forms of technical education. A review and critique of international developments in technology education, conducted by Don Ferguson, a member of the policy division of the Ministry of Education, led to a ministerial task force recommending in 1991 the establishment of technology as a learning area in its own right.[12, 13] Drawing heavily on the Scottish technology education model, Technology Education was developed into a curriculum statement, and introduced as the eighth learning area in the New Zealand Curriculum, in 1993.[14] Support for a coherent approach to technology education between secondary and tertiary was fostered through the 1990s by substantial Ministry funding to University of Waikato and then Massey University for research, resource development and pre-service and postgraduate teacher

[8] Harwood, C. D., & Compton V. J. (2007, Oct 3–5). *Moving from technical to technology education. Why is it so hard?* [Paper presentation]. The Technology Education New Zealand, Biannual Conference. Auckland.

[9] Department of Education. (1975). *Workshop Craft Curriculum Statement*. Wellington, NZ: Government Printer.

[10] Department of Education. (1977). *Workshop Technology Curriculum Statement*. Wellington, NZ: Government Printer.

[11] Compton, V. J. (2001). *Developments in technology education in New Zealand 1993–1995: An analysis of the reflections of key participant* [Unpublished doctoral Thesis]. University of Waikato, New Zealand.

[12] Ferguson, D. (2009). *Development of technology education in New Zealand schools: 1985–2008*. Wellington, NZ: Ministry of Education. http://technology.tki.org.nz/Teacher-education/Archived-papers/Development-of-technology-education-in-NZ-1985-2008

[13] Jones, A. T., & Carr, M. D. (1993). *Towards technology education (vol. 1)*. Working papers of the Learning in Technology Education Project. Hamilton, NZ: Centre for Science, Mathematics Education Research, University of Waikato.

[14] Ministry of Education. (1993). *New Zealand curriculum framework*. Wellington, NZ: Learning Media.

qualification development. The close interaction between concurrent research programmes and policy development would be a defining feature of the development of Technology Education in New Zealand, and New Zealand's global leadership. About the same time, polytechnics were starting to offer degrees, sometimes in technological disciplines, as well as their continuing technical or vocational education at sub-degree level.

2.2 Technology in the New Zealand Curriculum – the 1990s

The 1993 draft *Technology in the New Zealand Curriculum (TiNZC)* was revised following public consultation and academic research[15, 16, 17] and launched as a curriculum statement in 1995. In February 1999, TiNZC was gazetted as mandatory for all schools to teach from years 1 to 10.

TiNZC was based on two big ideas. The first big idea was that all students needed sufficient technological literacy to be able to educate and re-educate themselves to benefit from an ever-changing array of future technologies in the future. It was perceived that students' ability to live dignified and full lives as citizens of Aotearoa New Zealand depended on them having the skills to self-learn new technologies, but also make discerning choices about what and when technology should be chosen and applied.[18]

The second big idea was that students would benefit from learning about the process of developing technological solutions. Technology was perceived as informed or 'artful' doing, a purposeful, knowledge-rich process of working out practical ways to meet needs, address an issue or respond to an opportunity. This can be contrasted with the famed 'number 8 wire' model of improvisation or making do. It was desired that people of this country would be world-class technological innovators. As they progressed, students would become primary decision makers as they developed technological outcomes to address an issue, need or opportunity. This contrasted with the highly prescribed nature of technical education in which teachers rather than students made the most important decisions on how to make something that met a need.[19]

The 1995 curriculum was structured around three strands – technological knowledge and understanding, technological capability, and technology and society – and seven technological areas were identified as contexts for learning: biotechnology, electronics and control technology, food technology, information and communication technology, materials technology, production and process technology, and structures and mechanisms. It was expected that students would experience a range of these in any one year, and that across a multi-year programme of learning, students would undertake learning drawn from most or all of these contexts. 'Design' was positioned as integral to each area.

[15] Bell, B., Jones A., & Carr, M. (1995). The development of the recent national New Zealand science curriculum. *Studies in Science Education, 26,* 73–105.

[16] Jones, A. T., & Carr, M. D. (1993). *Towards technology education* (vol. 1). Working papers of the Learning in Technology Education Project. Hamilton, NZ: Centre for Science, Mathematics Education Research, University of Waikato.

[17] Jones, A. T., Mather, V. J., & Carr, M. D. (1994). *Issues in the practice of technology education* (vol 3). Working papers of the Learning in Technology Education Project. Hamilton, NZ: Centre for Science, Mathematics Education Research, University of Waikato.

[18] Compton, V. J. (2007, October 3–5). *The role of technology education in supporting a democratic literacy* [Paper presentation]. Technology Education New Zealand, Biannual Conference, Auckland.

[19] Harwood, C.D., & Compton, V. J. (2007, October 3–5). *Moving from technical to technology education: Why it's so hard!* [Paper presentation]. Technology Education New Zealand, Biannual Conference, Auckland.

The development of Hangarau is described by Lemon et al.[20] Like Technology, Hangarau was envisaged to be boldly different from technical education. Ideally it would be more than a translation of Technology: students would develop similar knowledge and skills to those learnt in Technology, but with a firm grounding in te āo Māori. Māori have always been innovative, with highly complex knowledge systems drawing on the natural world around them. It was recognised that there were unique kaupapa Māori that needed to be supported. Indeed, rangahau, the traditional method of inquiry, experimentation and reflection on what has been discovered has many parallels to technological practice. Much mātauranga Māori is technological in nature, including examples such as preservation of food, navigation, design of defence systems (pā) and use of plant-based medicines.

In Hangarau, technological practice should draw on mātauranga Māori (knowledge), tikanga Māori (cultural practices) and whakaaro Māori (Māori thinking). However, the development of an appropriate technical language was not unproblematic.[21] Further, as Lemon et al. report,[22] those undertaking the development were often constrained to make the curriculum fit within norms and templates defined for Technology, and by lack of research to support the curriculum development work.

The introduction of Technology and Hangarau as learning areas was challenging to both teachers and schools.[23] Both were strongly organised on disciplinary lines developed through their previous delivery of technical education, teaching rooms were not multi-purpose and there were timetabling issues. In order to support teachers to deliver the new multi-disciplinary curriculum, a subject association group for teachers, Technology Education New Zealand (TENZ), was established in 1996. The technical subject associations – Home Economics and Technology Teachers Association, New Zealand (HETTANZ) and New Zealand Graphics and Technology Teachers Association (NZGTTA) – added technology to their names but operated much as before. What was delivered in any particular secondary school reflected the makeup of the teaching workforce, the teaching rooms and equipment in existence, and the willingness of school leadership to move to Technology education as per the curriculum rather than continue previous technical education. Overlaid was the desire of the rapidly growing information and communication technology sector for greater recognition than being 'just' one of the learning contexts. The sector argued that, given the ubiquitous nature of digital technologies, their growing economic significance in both the domestic and export economies, and their importance to being a fully participating citizen in an increasingly digital society, digital technology needed recognition as a critically important subject for all students.

[20] Lemon, R., Lee, K,. & Dale, H. (2020). The marau Hangarau (Māori-medium Technology curriculum): Why there isn't much research but why there should be! *Australasian Journal of Technology Education.* https://ajte.org/index.php/AJTE/article/view/71

[21] McKinley, E., & Keegan, P. J. (2008). Curriculum and language in Aotearoa New Zealand: From Science to Putaiao. *L1 – Educational Studies in Language and Literature, 8*(1), 135–147.

[22] Lemon, R., Lee, K,. & Dale, H. (2020). The marau Hangarau (Māori-medium Technology curriculum): Why there isn't much research but why there should be! *Australasian Journal of Technology Education.* https://ajte.org/index.php/AJTE/article/view/71

[23] Harwood, C.D., & Compton, V. J. (2007, October 3–5). *Moving from technical to technology education: Why it's so hard!* [Paper presentation]. Technology Education New Zealand, Biannual Conference, Auckland.

2.3 The First NCEA Matrix in Technology

Preceding the introduction of NCEA in 2002, in the late 1990s and early 2000s it was necessary to develop a full assessment matrix. This matrix was primarily a generic Technology matrix at Level 1, although as presented it did not look like that. It had been argued that it would be helpful if the technological area in which a standard was achieved could be made available as information. This could not be done so instead several of the generic achievement standards were registered six times – once for each technological area (excluding process and production technology). It was further argued that there would be value if a small number of credits (4 at Level 2 and 3 at level 3) were available to recognise a high level of skill in executing manual dexterities.

The matrix was implemented from 2003. It addressed all three strands of the curriculum, although weighted towards technological practice via standards covering brief development, conceptual design and making of prototypes. There were specific standards for incorporation of technological knowledge and the nature of technology. However, even then it was possible to receive 14 credits by success in a narrow subset of the standards.

An existing subject in schools, Graphics, was renamed Design – Graphic Communication, and was supported by the Ministry of Education to develop its own suite of achievement standards. In allowing this, the Ministry of Education supported NCEA assessments to occur using achievement standards that were ex-curriculum. It appeared to be assumed that the Ministry foresaw an ageing teaching workforce without technology education knowledge, who would leave the workforce, and the subject could be progressively mainstreamed into Technology. The 2003 assessment matrix for this subject had all the externally assessed standards seeking demonstration of proficiency in the execution of technical drawing and modelling techniques, whereas the internally assessed standards did have some features overlapping the technology curriculum.

One issue that arose and was not satisfactorily resolved at the time was the question of progression – how did a student demonstrate progression between Levels 1 and 3? This was an issue of concern at the same time to the engineering profession internationally,[24] which was faced with the issue of defining the essential difference in competence between three levels of engineering professionals. Between 1999 and 2007 the International Engineering Alliance evolved an answer – the complexity of the problem and the activities undertaken to derive a solution were the key progression indicators.

At a similar time, the Ministry of Education let two contracts, one to Massey University (led by Harwood and Compton) and another to the University of Waikato (led by Jones, Moreland and Cowie), to undertake classroom-based research that explored assessment in technology. This work

[24] International Engineering Alliance. (2015). *A history of the International Engineering Alliance and its constituent agreement: Towards global engineering education and professional competence standards.* https://www.ieagreements.org/assets/Uploads/Documents/Policy/Graduate-Attributes-and-Professional-Competencies.pdf

led to a research-informed understanding of what student progression could look like when teachers were presented with curriculum-aligned professional development.[25, 26, 27, 28, 29]

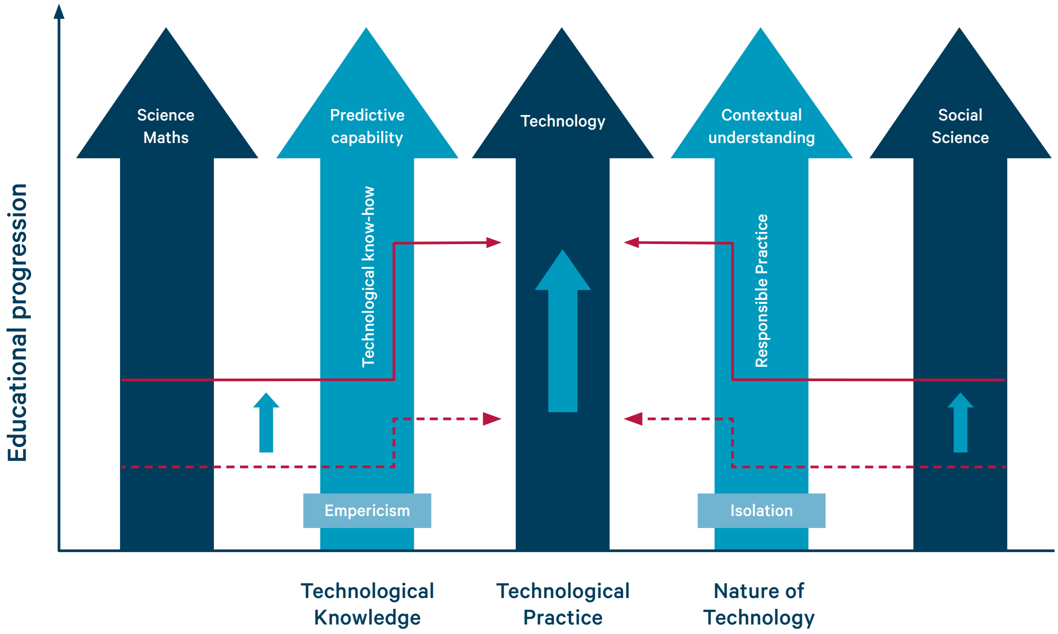
This work resulted in cross-fertilisation of the ideas to create a model for progression, commonly known as the technology staircase (see below).

2.4 Emergence of the Technology Staircase Model

The technology staircase model (Figure 1) is a conceptualisation of progression in Technology education, including engineering education. It was created in the late 1990s as a visual aid by staff at Massey University to illustrate why tertiary qualifications that are mostly technology- or engineering-rich prefer that in earlier years students focus on underpinning science and mathematical knowledge rather than progressing their learning in Technology. The underpinning premise is that increasing technological expertise (for example, moving from the dashed line to the solid line in Figure 1) requires increases in all the contributing attributes. These include science and maths (far left) and social science (far right).

FIGURE 1

The Technology Staircase Model for Progression



[25] Compton, V. J., & Harwood, C.D. (2003). Enhancing technological practice: An assessment framework for technology education in New Zealand. *International Journal of Design and Technology Education, 13*(1), 1–26.

[26] Compton, V. J., & Harwood, C. D. (2005). Progression in technology education in New Zealand: Components of practice as a way forward. *International Journal of Design and Technology Education, 15*(3), 253–287.

[27] Jones, A. T. (2009). Towards an articulation of students making progress in learning technological concepts and processes. In A. T. Jones & M. J. de Vries (Eds.), *International handbook of research and development in technology education* (pp. 93–104). Rotterdam, Netherlands: Sense.

[28] Moreland, J., & Cowie, B. (2009). Making meaning in primary technology classrooms through assessment for learning. In A. T. Jones & M. J. de Vries (Eds.), *International handbook of research and development in technology education* (pp. 461–476). Rotterdam, Netherlands: Sense.

[29] Moreland, J. (2009). Focusing on the learner and the subject. In A. T. Jones & M. J. de Vries (Eds.), *International Handbook of research and development in technology education* (pp. 445–448). Rotterdam, Netherlands: Sense.

At the simplest level, the model considers a person without knowledge of science and mathematics as a trial-and-error empiricist. However, as they learn more science and mathematics, their technological know-how becomes more model-based prediction. Hence, it is generally necessary to draw on higher levels of science and mathematics in order to progress their technological knowledge. This makes sense in practice. As the International Engineering Alliance[30] has established, a student entering a four-year BE(Hons) degree is expected to study calculus to 200 level in university, whereas a person entering an engineering-based trade studies calculus will do so to a lower level. Figure 1 explains the practical caveat that when a person seeks to go from a lower-level qualification in technology (for example, the Level 6 NZ Diploma of Engineering) to a higher level (for example, the Level 8 BE(Hons)), they have to catch up on mathematics and science.

The right-hand side of the model addresses the purposeful nature of technology; that is, it exists in and has to be fit for social contexts. Hence, a technologist needs knowledge of society drawn from the social sciences. Drawing on knowledge of society, environment and culture, a technologist develops contextual understanding of how technology interacts both positively and negatively with society – how technology can change society (for example, the internet) and how society can accept or reject technological advances (for example, nuclear power). Without any contextual knowledge, a person acts in isolation, but with increasing contextual understanding that person can become a technologist undertaking their activities more responsibly.

Technological practice occurs when technological knowledge is applied purposefully, within a social context, so the outputs of the practice are fit for purpose. Progression in technological practice is indexed to the increasing complexity of the issue/need/opportunity and the increasing complexity of the methods used to develop the solution. Box 1 provides a simple example.

The staircase model thus shows how the three strands of the curriculum work together. It also highlights one of the biggest challenges for Technology education: progression often requires new learning in both the social sciences and in the underpinning mathematics and sciences. In practice, the new learning in the social sciences can likely sometimes be gained informally, or through engaging specific experts on project teams. Increasing pre-requisite maths/science knowledge more often requires formal learning. Just as higher-level Technology educational programmes in a specific discipline often require input from other learning areas so the student can progress their technological proficiency, insufficient knowledge from other learning areas, especially mathematics or science, could limit school student progression in some technological areas.

While the staircase model has been developed from thinking about industrial technologies, it is more widely applicable. For example, progression in digital technology will often require advancement in knowledge of computer science, which is typically seen to lie in the mathematical domain. Practical knowledge cannot usurp the need for computational thinking; that is, basic knowledge of computer science. The staircase model thus affirms that the know-hows of technology are strongly knowledge-based, and the successful student needs a sound theoretical understanding to a much greater extent than needed for the older technical education replaced in the curriculum in the 1990s.

[30] www.ieagreements.org

BOX 1

Bridging the gap – a hypothetical example of progression based on complexity

Take the problem of bridging a 2m gap. At a lower level, this problem can be envisaged as no more than creating a simple bridge over a sometimes boggy piece of ground, using a nearby heap of wooden planks. There is no consequence of failure other than wet feet, and no safety concern from missed footing. Equipped with a tape measure, the student can select a long enough piece of wood, grapple with the idea of how thick is thick enough, and test possible solutions, including addressing any difficulties of moving the plank to site.

The problem can be re-envisaged as a need to bridge glacial crevasses up to 2m wide to assist a climbing team. For this context, the device must be highly portable, light, strong and able to be launched from one side and recovered from the other side of the gap assuming high unstable sides of the crevasse. One can envisage a telescoping or folding device, the structure designed by advanced mathematical modelling of the stresses and strains, and linked to a wide search for suitable materials for each possible structure – metals, composites, plastics, etc. There is no appetite for trial and error.

A number of intermediary levels of complexity could be envisaged, but broadly speaking progression can arise from the nature of the issue/need/opportunity demanding more complex approaches be taken in the technological practice, and/or by using more advanced knowledge in the practice.

The staircase model also emphasises that if we wish to create technologically literate citizens (one of the Curriculum big ideas is that every student leaving school has sufficient technological literacy to be able to responsibly select from and use an array of new technologies they have never seen) then their learning programme cannot focus purely on practical doing (the left-hand side of the model diagram). To be literate their programme must also include the right-hand side: the nature of technology strand.

The staircase model also emphasises that if we wish to create technologically literate citizens (one of the Curriculum big ideas is that every student leaving school has sufficient technological literacy to be able to responsibly select from and use an array of new technologies they have never seen) then their learning programme cannot focus purely on practical doing (the left-hand side of the model diagram). To be literate their programme must also include the right-hand side: the nature of technology strand.

2.5 Curriculum Changes and Implementation in the 2000s

In the early 2000s, the Ministry's *National School Sampling Study (NSSS)* gave teachers an opportunity to share their experience of implementing TiNZC.[31] A major outcome of the *NSSS* was a decision to redefine the 1993 *New Zealand Curriculum Framework* and develop new curricula for all learning areas under the *New Zealand Curriculum and Marautanga Project (NZCMP)*. As a result, *TiNZC* was reviewed and a *Learning Area Statement (LAS)* that redefined Technology was developed:

> In technology, students learn to be innovative developers of products and systems and discerning consumers who will make a difference in the world.[32]

The overall aim of Technology, of allowing students to develop 'technological literacy' through participating in Technology education, was therefore retained in the Technology *LAS*. However, the concept of technological literacy and how it was attained was extended, moving away from being solely related to undertaking technological practice.[33] This change was in response to limitations found during implementation of the *TiNZC: TiNZC* contended that supporting students to undertake technological practice from a strong sociological focus enabled them to "move their technological literacy away from a 'functional' orientation to a literacy that was 'liberatory' in nature".[34] While this argument was in keeping with contemporary sociological understandings of technology and technological practice at the time,[35, 36, 37, 38] evidence gained from senior secondary NCEA examination results indicated that the nature of students' technological literacy was limited.[39] It was identified that this limitation was due to student knowledge and skill development being solely immersed within technological practice.[40, 41]

Research findings from the NSSS found that where teachers had received sufficient professional development and were in supportive environments with suitable resources, there was good student learning that generally matched the intent of the curriculum, particularly in primary

[31] McGee C. D., Jones A. T., Bishop, A. R., Cowie B. M., Hill, M. F., Miller, T. F., Harlow, M. A., & Cram, C. J. (2001). *Curriculum Stocktake: National School Sampling Study. Milestone 2: Report on the first round of questionnaires: General, Mathematics, Technology, Māori Medium.* Hamilton, NZ: Waikato Institute for Research in Learning and Curriculum, Centre for Science and Technology Education Research and Māori Education Research.

[32] Ministry of Education. (2007). *The New Zealand curriculum.* Wellington, NZ: Learning Media.

[33] Compton, V. J. (2009). Yep – we can do that: Technological response to the curriculum 'needs' arising… *Design and Technology: An International Journal, 14*(1), 21–35.

[34] Compton, V. J. & Harwood, C. D. (2008). *Discussion document: Design ideas for future technology programmes.* http://nzcurriculum.tki.org.nz/content/download/482/3705/file/technology-design-ideas.do

[35] Barnett, M. (1995). Literacy, technology and technological literacy. *International Journal of Technology and Design Education, 5*, 119–137.

[36] MacKenzie, D., & Wajcman, J. (Eds.). (1985). *The social shaping of technology.* Maidenhead, UK: Open University Press.

[37] Pacey, A. (1983). *The culture of technology.* Oxford, UK: Blackwell.

[38] McGinn, R. (1990). What is technology? In L. Hickman (Ed.), *Technology as a human affair* (pp. 10–25). New York, NY: McGraw-Hill.

[39] Compton, V. J. & Harwood, C. D. (2008). *Discussion document: Design ideas for future technology programmes.* http://nzcurriculum.tki.org.nz/content/download/482/3705/file/technology-design-ideas.do

[40] Compton, V. J. (2010a). *Technology curriculum support: Explanatory papers.* http://technology.tki.org.nz/Curriculum-support/Explanatory-Papers/Technological-Practice/Brief-Development

[41] Compton, V. J. & Harwood, C. D. (2008). *Discussion document: Design ideas for future technology programmes.* http://nzcurriculum.tki.org.nz/content/download/482/3705/file/technology-design-ideas.do

schools.[42] However, in many secondary schools the constraints imposed by inflexible resources, reluctance of teachers and management to move on from technical education, timetabling and so on meant that implementation was patchy. There was also some suggestion that, across all year levels, students were not achieving the level of informed criticality that *TiNZC* required.[43] It was hypothesised that this situation was due to Technology programmes focusing on "developing students' understandings of and about technology almost exclusively within the context of their own technological practice".[44] Therefore, it was argued that the *TiNZC* failed to develop students who understood generic technological concepts, or who had philosophical understandings about technology and the outcomes of technological development. To redress this situation, it was argued that a stronger curriculum focus needed to be placed on the 'philosophy of technology' and on the 'generic concepts' underpinning technological practice.[45, 46]

The Technology learning area of *The New Zealand Curriculum*[47] was therefore structured around three new strands: Technological Practice, the newly defined Nature of Technology, and Technological Knowledge;[48] and eight new components with defined achievement objectives for curriculum levels 1–8. These new strands and components were included to allow "students to develop a broad technological literacy that will equip them to participate in society as informed citizens and give them access to technology-related careers".[49]

To support the development of the 2007 TiNZC, classroom-based research into progression in Technology learning in New Zealand schools was undertaken,[50, 51, 52] which led to the development of the Indicators of Progression. These indicators described the competencies and skills that students should develop from curriculum levels 1–8 (Year 1–13) for the eight strand components of Technology:

Technological Practice

- Brief development
- Planning for Practice
- Outcome development and evaluation

Technological Knowledge

- Technological Modelling
- Technological Systems
- Technological Products

Nature of Technology

- Characteristics of Technology
- Characteristics of Technological Outcomes

A set of indicators of progression at curriculum levels 6–8 was then written for 22 different technology specialist knowledge and skill strands (components) to support teachers to introduce the new curriculum.

At the same time the new curriculum was being developed, 10-year Ministry funding (2003–2013) was allocated to help raise the quality and effectiveness of teaching and learning in senior secondary school technology courses, and to increase participation. The funding focused on building teacher capability, supporting interactions with community experts, and improving alignment between secondary and tertiary technology education.[53] Deliverables included the appointment of a National Co-ordinator for Technology Education and National Technology Professional Development Manager; support for curriculum leaders via regional workshops; and a Beacon Practice project.[54] This project included 41 teachers, chosen after demonstrating they were then among the best performing teachers of Technology in New Zealand. A key focus of the Beacon Practice project was on enhancing student learning in technology through supporting and enhancing teachers' practice. The development of teacher resource material to support the professional development of all teachers involved in technology education in New Zealand was also an expected outcome of this project. These materials were initially published on Techlink[55] (later transferred to Technology Online) and were also used by technology in-service advisers and pre-service lecturers to support them in their development of technology teachers.

Much has been written about the importance of teacher professional learning as the means to enhance both teacher knowledge and the learning outcomes for students. The concepts a teacher or pre-service student holds regarding technology and technology education influence the teaching and assessment approaches. Jones et al[56] also found that even when teachers have developed broader notions of technology and technology education, these can be influenced by the subject sub-cultures in schools or regions. Although the Ministry supported the early implementation of the Technology achievement standards, this has declined significantly and as a result there has been limited expansion of a broad-based technology curriculum in schools.

[42] Harwood, C. D. (2006). *Fourth New Zealand beacon practice — Technology: Supporting student learning and resource development in technology education* [Paper presentation]. Biennial International Conference on Technology Education Research Conference: Values in Technology Education. Surfers' Paradise, Queensland, Australia.

[43] Jones, A. T., & Compton, V. J. (2009). Reviewing the field of technology education in New Zealand. In A. T. Jones & M. J. de Vries (Eds.), *International handbook of research and development in technology education* (93–104). Rotterdam, Netherlands: Sense.

[44] Compton, V. J. & Harwood, C. D. (2008). *Discussion document: Design ideas for future technology programmes.* http://nzcurriculum.tki.org.nz/content/download/482/3705/file/technology-design-ideas.do

[45] Compton V .J. (2004). *Technological knowledge: A developing framework for technology education in New Zealand.* Briefing Paper prepared for the New Zealand Ministry of Education Curriculum Project. http://nzcurriculum.tki.org.nz/Archives/Curriculum-project-archives/Developing-the-draft/Technology/Background-reading

[46] Compton, V. J., & Jones A. T. (2004). *The nature of technology.* Briefing paper prepared for the New Zealand Ministry of Education Curriculum Project. Wellington, NZ: Ministry of Education.

[47] Ministry of Education. (2007). *The New Zealand curriculum.* Wellington, NZ: Learning Media.

[48] Compton V. J., & France B. (2007). Redefining technological literacy in New Zealand: From concepts to curriculum constructs. In *Proceedings of the Pupils' Attitudes Towards Technology (PATT 18) international design and technology education conference: Teaching and learning technological literacy in the classroom* (pp. 260–272). PATT.

[49] Ministry of Education. (2007). *The New Zealand curriculum.* Wellington, NZ: Learning Media.

[50] Compton, V. J. & Harwood, C. D. (2010). *Indicators of progression: Technological practice.* http://technology.tki.org.nz/Curriculum-support/Indicators-of-Progression/Achievement-Objectives/Technological-Practice

[51] Compton V. J & Compton, A. D. (2010). *Indicators of progression: Technological knowledge.* http://technology.tki.org.nz/Curriculum-support/Indicators-of-Progression/Achievement-Objectives/Technological-Knowledge

[52] Compton V. J & Compton, A. D. (2010). *Learning progression diagrams.* http://technology.tki.org.nz/Curriculum-support/Progression-Diagrams

[53] Jones, A., & Buntting, C. (2016). Technology education in New Zealand: Embedding a new curriculum. In M. J. Beaon, S. Fletcher, S. Kruse, P. Labudde, M. Lang, I. Mammes et al. (Eds.), *Technology Education Today. International Perspectives* (pp. 213–232). Kornwestheim, Germany: Waxmann.

[54] Harwood, C .D. (2006, December 7–9). *New Zealand beacon practice — Technology: Supporting student learning and resource development in technology education.* [Paper presentation]. Fourth Biennial International Conference on Technology Education Research Conference: Values in Technology Education. Surfers' Paradise, Queensland, Australia.

[55] Fox-Turnbull, W., & O'Sullivan, G. (2013). Supporting conceptual understandings of and pedagogical practice in technology through a website in New Zealand. *International Journal of Technology and Design Education, 23,* 391–408.

[56] Jones, A. T. (2009). Towards an articulation of students making progress in learning technological concepts and processes. In A. T. Jones & M. J. de Vries (Eds.), *International handbook of research and development in technology education* (pp. 93–104). Rotterdam, Netherlands: Sense.

2.6 NCEA Changes Between 2007 and 2013

Between 2007 and October 2010, the engineering sector undertook a major workforce study in response to shortages in entrants to the engineering and related trades workforces. The resultant National Engineering Education Plan envisaged the need for pathways through senior high school into levels 5 and 6 qualifications. It proposed that there be NCEA assessments in three domains: 'construction and mechanical technologies', 'digital technologies' and 'processing technologies', retaining what would be termed Design & Visual Communication as a fourth domain. The rationale was that as well as assessment in the generic technological knowledge, nature of technology and technological practice, there would be benefits if those students who learnt technological knowledge specific to such a domain could progress along a specific pathway into tertiary education. This development was informed by a study[57] to determine if achievement standards were fit for purpose in assessing students' technological literacy.

Additionally, from 2009 to 2011 the original Design – Graphic Communication assessment matrix was re-developed. In the renamed Design & Visual Communication (DVC), the externally assessed standards were largely retained, seeking demonstration of proficiency in the execution of technical drawing and modelling techniques, whereas the internally assessed standards partly shifted towards visual communication. The result was a reduced fit with the Technology curriculum, including the disappearance of assessment of the nature of technology. In order to achieve coverage of the Technology curriculum in the DVC domain, it would be necessary to draw on the generic standards for nature of technology and some aspects of technological practice.

As a consequence of the work under the National Engineering Education Plan project, the Technology curriculum was amended by the Ministry to replace the seven technological areas in which technology might be explored with the four domains. This did not mean that there was any less requirement to provide learning across the whole curriculum, but rather that the technological knowledge might be more specifically defined in a particular domain. There was consequential redevelopment work in the NCEA, generating the 2011 assessment matrix. The premise was that the generic standards would be used for technological practice and the nature of technology, but in each domain, domain-specific knowledge would be introduced. This knowledge was still intended to be principle-based, covering broad concepts in the domain, so that knowledge was transferable. The multiple registration of generic standards was dropped.

In Processing Technologies, standards for knowledge about processing, packaging and preservation were introduced in 2011 to sit alongside the practical workmanship standard. In Construction & Mechanical Technology, domain-specific knowledge incorporation had two stages. In 2011, standards for knowledge of structures and machines were introduced. By 2013, in response to requests from teachers, the workmanship standard was replicated for textile and resistant materials, and standards were created for demonstrating knowledge of 'concepts for making' products with resistant and textile materials. A pattern design standard was also introduced.

In Digital Technology, the domain-specific standards assessed mainly domain-specific knowledge and practical implementation. To obtain coverage of the Technology curriculum, the intention was that the generic standards would continue to be used.

[57] Compton, V. J., & Harwood, C .D. (2004). Technology education achievement standards: Are they fit for the purpose? In *3rd Biennial International Conference on Technology Education Research. Learning for Innovation in Technology Education* (pp. 140–149).

A Technology Scholarship assessment was also made available. This portfolio assessment was holistic and broad-based, requiring students to author a reflective report that demonstrated their technological literacy at the appropriate level of achievement. As such, it required students to provide assessment evidence that demonstrated their understandings and competencies in Technology from a holistic and broad-based perspective.

In summary, under the 2011–2013 Level 1–3 Technology assessment matrix, in order to assess a curriculum-true programme of learning, it was necessary to use both some of the generic standards and some of the domain-specific standards. However, the number of standards now available was so large that teachers could design programmes of learning to enable students to achieve 14 credits from only restricted aspects of the curriculum.

2.7 Strengthening Digital Technology

From 2007, the ICT community strongly lobbied for ICT-specific standards, written in the language of the ICT community. For a time, they were rebuffed with the argument that the generic standards could be supported by resource materials that would make clear how the standards related to the ICT sector.

In 2016, a government policy decision meant that digital technology would be compulsory in Years 1–10. At that time, the ICT sector successfully argued with the Ministry that there should no longer be reliance on the generic Technology standards in NCEA, but that digital technology should have a full suite of its own achievement standards. These were introduced in 2017 (Level 1) and 2018 (Levels 2 and 3).

The curriculum for Technology was amended to recognise five so-called technological areas:

- Computational thinking for digital technologies.
- Designing and developing digital outcomes.
- Design & visual communication.
- Designing and developing processed outcomes.
- Designing and developing materials outcomes.

However, Technology's three curriculum strands and their components, including the achievement objectives that defined learning intentions, remained unchanged, as were the titles of the four domains in the NCEA achievement matrix for Technology.

Hangarau Matihiko was introduced as a specific strand within Hangarau to parallel digital technology.

It is the Panel's assessment of this set of changes that:

1. When the Digital Technologies NCEA standards are tested against the Technology curriculum, there is good coverage of technological practice and technological knowledge relevant to this domain, but weak coverage of the nature of technology – this latter is particularly important given the ethical issues associated with digital technologies.
2. The new area, 'Computational thinking for digital technologies' lacks coherence as a technological area – it is really a service area of computer science perhaps mixed with some technological knowledge – as can be readily seen in the technology staircase model. In the NCEA matrix, there are a small number of credits that can be assigned to computational thinking.

3. While the description for Design & Visual Communication (DVC) locates the area within Technology, the concept of visual literacy overlaps with the creative arts. However, if a programme is designed to prepare students for the DVC assessment standards only, these students will likely experience a programme with weak coverage of the nature of technology and may not encounter some of the key elements of technological practice.
4. The concept of 'materials outcomes' was introduced and the more globally acceptable idea of focusing on the know-how (construction, mechanics) was reduced. The idea of 'materials outcomes' is a largely localised construct, developed from the terminology adopted by teachers in this country. Materials knowledge (where materials are needed to achieve a technological outcome) is important, but it is an input into the essential ethos of technology – know-how used in a purposeful manner. Further, excellent technological practice can occur without use of physical materials.

In hindsight, the changes could have been interpreted by teachers that it was permissible to shift away from addressing the broad big ideas of the curriculum that emphasise the multi-disciplinary nature of technology, to narrow, skill-based learning programmes. Skill-based learning programmes might then be standardised, downplaying the desired objective of student-led decision-making. Transferable knowledge could be substituted by specific knowledge of the day particular to the domain of study, the knowledge that many teachers tend to be most confident in teaching.

In effect, by a series of incremental changes, largely in response to the petitions of lobby groups, the totality of the curriculum and the senior school assessment in the Technology learning area lost its coherence around the big ideas and the three fundamental strands of the curriculum at the core of the Technology learning area.

Wāhanga Tuatoru

3. NCEA Standards in Technology and Their Use

3.1 Current NCEA Achievement Standards in Technology

Table 1 presents the matrix of achievement standards currently available for Technology. The plethora of standards is at odds with the relatively small number of students studying technology in senior secondary school (see Section 3.2 below). Additionally, there are standards in most domains that are not fully aligned to the curriculum.

The Construction and Mechanical Technologies (CMT) and Processing Technologies (PT) achievement standards are intended to be used in an integrated way with the generic standards. In contrast, both Digital Technology and Design & Visual Communication have large suites of their own achievement standards. However, as stated above, neither suite sufficiently addresses the nature of technology, and in the latter the coverage of some other aspects of the Technology curriculum is weak, meaning that the generic standards are still needed in order for students to be assessed against the full Technology curriculum.

[58] NZQA – NCEA Insight Report Summary – Technology Learning Area 2014-2018. (Internal report provided by the Ministry of Education.)

TABLE 1

NCEA Credits Available via the Suites of Technology Achievement Standards

SUITE	LEVEL 1	LEVEL 2	LEVEL 3
Generic Technology	61	58	54
Construction & Mechanical Technologies (CMT)	30 (10 + 2 x 10) (in effect 20 – 10 of these are repeated for resistant materials and textiles)	30 (10 repeated)	32 (10 repeated)
Processing Technologies (PT)	12	12	10
Design & Visual Communication (DVC)	25	29	28
Digital Technologies (DT)	43	45	45
TOTAL	**171**	**174**	**169**

3.2 Achievement Standard Use 2014–2018

An NZQA report on achievement standard use between 2014 and 2018[58] showed that approximately 17,000 students (of the total of about 60,000) engaged with the Technology and/or Hangarau learning areas at Year 11, 10,000 at Year 12 and 7,000 at Year 13. Only 4,800 students studied Technology subjects continuously between 2016 and 2018. The number of students studying Technology as a continuing learning pathway through all three years is thus small (approx. 8%). Students entered and left the learning area in significant numbers between both years 11 and 12, and years 12 and 13.

Table 2 presents the number of students in what the report termed 'strands' in 2018. As can be seen, total numbers decrease as the level of schooling increases, although the relative proportion of students taking CMT, PT or general Technology standards increases as the level of schooling increases.

TABLE 2

Students Engaged with Technology Achievement Standards (2018)

	Digital Technology	Design & Visual Communication	All other Technology (excl. Hangarau)	TOTAL (excl. Hangarau)
YEAR 11	4,755 (35%)	5,610 (41%)	3,244 (24%)	**13,609**
YEAR 12	2,229 (29%)	3,037 (40%)	2,382 (31%)	**7,648**
YEAR 13	1,681 (29%)	1,982 (34%)	2,056 (36%)	**5,719**

NOTE: Percentages are the percentage of all Technology achievement standards for each year group

In a further Insights Report[59] showing engagement with specific achievement standards (as distinct from specific subject enrolment), generic Technology standards with significant student numbers were those that involved making a prototype (of the order of 7,000 at Level 1; 4,000 at Level 2; and 3,000 at Level 3) and developing a conceptual design (5,500; 4,000; and 3,000, respectively). Developing a brief was next most popular (4,000; 2,500; and 2,000). A number of standards were barely used.

Standards for implementing procedures had some student volume in both CMT – Construction & Mechanical Technologies (4,500; 2,200; and 1,300 for resistant materials; 2,000; 1,100; and 800 for textiles) and PT – Processing Technologies (3,000; 1,200; and 800). Those that required demonstration of technological knowledge in the domain were barely used.

In contrast to the internally assessed standards, relatively low student volumes attempted the externally assessed standards. The most popular standards were those related to knowledge of modelling, material properties and features of designs.

This pattern of generic, CMT and PT standard use is consistent with relatively narrow learning programmes. Students seemed likely to have studied in a single domain, and in that domain to have developed a brief, made a prototype and/or developed a conceptual design, and received credit for practical implementation (all internally assessed). They might have also sought a small number of external credits for modelling and materials knowledge. It is a pattern that suggests that many teachers are delivering programmes quite similar to the old technical education programmes the 1995 curriculum was intended to replace. Broad-based technological literacy is generally not assessed.

For DVC[60] – where engagement was measured by the taking of sufficient standards rather than by subject engagement – the numbers engaged were of the order of 8,000; 4,500; and 2,800 at Levels 1, 2 and 3, respectively. Because the total number of credits available in the DVC domain is less than 30, to attempt 14 or more credits the majority of the standards must be taken. However, a student whose programme is drawn entirely from within the DVC domain may not be assessed for broad-based technological literacy.

The external assessments – for exploring and communication design ideas, for example, through sketching, and for preparing drawings – had significant student numbers at all three levels.

In the internal assessment, DVC further sub-divided into a visual communication strand in which the use of techniques, for example, rendering, and the communication of design ideas were relatively popular; and both the graphics practice strand and the design heritage strand were also well used.

Very little assessment has been carried out using the Hangarau achievement standards. Data from NZQA, made available to the Panel by the Ministry, show that only internally assessed standards have been used in recent years, and the total student count has rarely been above that of a single class (20–30 students nationwide).

[59] NZQA NCEA Assessment Insights Report for Technology (Generic, CMT and PT) – 28 August 2019. (Internal report provided by the Ministry of Education.)

[60] NZQA NCEA Assessment Insights report for Design & Visual Communication – 28 August 2019. (Internal report provided by the Ministry of Education.)

[61] Engler, R. (2010). *Are particular school subjects associated with better performance at university?* Wellington, NZ: Ministry of Education. https://www.educationcounts.govt.nz/__data/assets/pdf_file/0007/79342/Are-Particular-School-Subjects-Associated-with-Better-Performance-at-University.pdf

The Panel recognises that the Digital Technology achievement standards have only been available since 2017, and so it is too early to see patterns of use emerge. Data from NZQA, made available to the Panel by the Ministry, show that the most popular standards at Level 1 have been those in which students develop computer programmes, and use iterative processes to develop a digital outcome. Developing a design for a digital outcome has also been well used. Much less use has been made of standards involving electronics outcomes, managing data and proposal development. This pattern of greater use of the practical 'doing' standards associated with software rather than hardware persists into Levels 2 and 3. At Level 1 reasonable numbers of students attempted the external standard on human-computer interaction. However, the bulk of assessment attempted was internal. Overall, as is the case for the other Technology domains, assessment has been skewed towards technological practice.

Wāhanga Tuawhā

4. Secondary to Tertiary Pathways

4.1 Secondary–Tertiary Pathways Defined

While the Panel acknowledges that each student has their own unique pathway or learner journey, the Panel has adopted the definition of a secondary–tertiary pathway as an identifiable path taken by a significant number of students. Thus, the key criterion for the existence of a successful pathway is a measure of standardisation – a large number of prospective students, irrespective of which school they attended, have taken some substantially equivalent components within their programme of learning at school, all achieving or surpassing a specified minimum level of achievement. The tertiary provider can then start all the students at essentially the same entry level. This is educationally efficient, particularly for tertiary programmes of learning that are prescribed rather than based on an elective structure.

Engagement on a recognised pathway to a career opportunity may also be effective in motivating students.

In contrast, over-specialisation at any early stage in the educational journey can work against the existence of pathways; students can inadvertently cut off future options.

Creating pathways through standardised use across many schools of the Technology achievement standards will not easily occur because the choice of standards available is so great, and because both subject offerings and learning programmes within subjects vary significantly between schools.

4.2 Levels 6 and Above

Pathways from secondary to tertiary programmes are long established through the professional degree programmes. Medicine, engineering and veterinary science are examples in which there is a widely known set of subjects an aspiring student needs to take in Years 12 and 13 in order to achieve entry into the tertiary programme. If a student fails to take the set of subjects, they may be faced with catch-up study in order to fill in gaps in their starting knowledge. For example, students wishing to study engineering who took a school programme that was light in calculus generally need to improve their knowledge of calculus prior to being allowed to enrol for engineering study.

In 2010, the Ministry of Education's data analysis group undertook a major study seeking to correlate university success with school achievement.[61] The conclusion was that higher performance at university is more closely related to how well students performed in general at school, rather than to the particular school subjects they studied. This applied to a broad range of school subjects, and to nearly every field of study at university. Nevertheless, there were some skills and knowledge that do appear to be important to performance at university. For example, mathematics at school was associated with better performance in mathematical science, chemistry with chemical science and English with studies in law. In engineering, there was definite advantage for those students who had studied physics, mathematics with calculus and chemistry at school.

In the National Engineering Education Plan work carried out between 2007 and 2010, extensive consultation with universities and polytechnics offering technology and engineering showed no specific benefit of school achievement in Technology being a pre-requisite for any qualification at Level 6 or above – even though Technology was by then part of the canon of subjects for University Entrance. The really important pre-requisites were physics, chemistry and mathematics. At best, Technology was helpful in a general manner. This outcome is fully consistent with the Technology staircase model discussed earlier.

To date, universities and polytechnics offering Level 6 and above qualifications in information science have seen few students who have studied Digital Technology to Year 13 and been assessed in the subject at Level 3. The Technology staircase model suggests that for those progressing to university degrees in information science, the benefits will be most dependent on how advanced the student has become in computational thinking. The Panel received anecdotal evidence from the polytechnic sector that, due to the more applied nature of information technology programmes in that sector, successful study in Digital Technology at school could be recognised as beneficial although not a necessary pre-requisite. As an example, in two polytechnics, their Information Technology programmes at Levels 4–7 have entry requirements that do not specifically require Digital Technology standards. However, there have been two benefits to the introduction of NCEA achievement standards in this domain. The first is that students who have studied Digital Technology are better informed about the field of Information and Communication Technology and tend to remain in the programmes – they do not get part way through their study and decide that ICT is not for them. The second area where Digital Technology standards are useful is where enrolling students may be applying for special entry into the programmes. If a student has achieved Digital Technology standards, the polytechnics confidently use this as evidence of their likelihood to succeed in their chosen programme of study.

An additional pathway from Technology to tertiary study at Levels 6 and above is into design qualifications. The Panel is aware that high achievement in Technology subjects is being used as a method for entry into at least one university's selected-entry design programme.

Technology at Scholarship level assesses for advanced technological literacy using a portfolio of evidence submitted by the student. The 2010 study by the Ministry of Education cited earlier in this section suggests that scholarship achievers have high likelihood of success, irrespective of their tertiary pathway. An example as an illustration of the benefits of scholarship in Technology is shown in Box 2.

[62] Sweet Analytics. (n.d.). *Evaluating BCATS.* https://sweetanalytics.co.nz/content/evaluating-bcats/

BOX 2

A parent about her daughter who gained an Outstanding Technology Scholarship in 2006

Technology improved Kate's work ethic, her ability to solve problems and develop solutions. It also enhanced her eagerness to learn. Technology developed all of these attributes, which made her a very attractive prospect to her current employer. She has found that these skills developed and nurtured by technology have helped her tremendously in her current career as a banking consultant. Although on the surface, banking and technology seem light years apart, the skills and disciplines learnt during her time studying technology apply to many areas in various workforces.

4.3 Levels 5 and Below

Industry Training Organisations have designed learning programmes, assessed by unit standards, to be delivered to secondary school students, which align with the entry into a trade qualification at Level 5 or below. Several such programmes are currently delivered to Year 12–13 students.

Perhaps the best-known programme is BCATS, or the National Certificate in Building, Construction and Allied Trades Skills at Levels 1 and 2 – a series of unit standards for high school students introducing them to the skills required for building, construction and allied trades. These standards were designed to encourage more secondary students to move into the trades. A recent study of the effectiveness of BCATS[62] showed their use is increasing: almost 10% of 2016 school leavers completed a standard compared with 5% in 2009. The majority of those who take the standards will complete level 2 of the BCATS.

The study reported that progression into enrolling with an ITO after completing the BCATS standard is often not immediate. One year after completing the BCATS standards, 9% of individuals are enrolled with an ITO. However, 10 years after completing the BCATS qualification, roughly 30% will have completed training with an ITO, with an additional 3% still enrolled with an ITO and 16% having their training incomplete.

The study further reported that of those who only completed the first stage of the BCATS, 24% had finished training with an ITO eight years later; 26% of those who completed both stages had completed training in the same time frame. This demonstrated that there was a slightly higher completion rate for ITO qualifications for those who do both BCATS standards. In general, BCATS alumni take half a year between finishing school and starting training with Building and Construction Industry Training Organisation (BCITO), while those with no qualification take a year longer.[63] Thus, BCATS standards are correlated with a decrease in the time individuals spend between school and starting an apprenticeship with BCITO. The study concluded that BCATS alumni are also more likely to succeed in their building qualification and stay in the industry.

Very similar results are reported for the mechanical engineering gateway offered by Competenz[64] and the electrotechnology gateway offered by Skills Org.[65]

It is not known whether also completing Technology achievement standards is a contributing factor – this was not evaluated in the studies available.

4.4 Pathways to Wānanga Programmes

Students enter the three Wānanga with a variety of backgrounds and at a variety of career stages. Recent school leavers are but one minority group of entrants. Nevertheless, the Wānanga have found that successful progression in a broad range of their programmes is assisted by digital technological literacy. One Panel member informed the Panel that in a 2018 survey at one Wānanga, 40% of respondents reported as either having no technological confidence or only being somewhat confident. While this might be attributed to the average age of Wānanga students, it could also be impacted by the fact that few of those with very little technological confidence are likely to fill out an online survey. There is anecdotal evidence of students coming straight from secondary school without high levels of digital fluency.

While not currently having direct Digital Technology pathways available, the three Wānanga have sought to improve digital fluency skills of kaimahi (staff) and tauira (students). They have adopted a range of strategies, including eLearning opportunities and physical digital technology hubs that promote digital inclusion and Indigenous innovation. These initiatives both embed digital technology in the unique learning frameworks in which they exist and apply critical analysis to the use of digital technology.

The 2011 UNESCO policy brief on ICTs and Indigenous People found that digital technology can be likened to a "two edged sword" with its ability to enhance cultural knowledge or contribute to its continued erosion.[66] The Wānanga initiatives promote Indigenous knowledge as dynamic and changing, while still being grounded in their basic principles of tikanga.[67] As Wolfgramm[68] states, "If it is to be sustainable, the way in which a technology enters an Indigenous community must reflect and animate the principles, values, and philosophies of Indigenous learning processes and world view."

Two Panel members communicated their personal experiences at Wānanga. At Te Whare Wānanga Awanuiārangi, the Tech Pā supports an after-school programme for secondary school rangatahi, as well as Wānanga tauira and online learning through eWānanga. Te Wānanga o Aotearoa created their Te Toiotua programme for kaiako and tauira to engage in culturally sustaining digital technology experiences. Both these initiatives were set up as a response to the understanding that digital technology without critical analysis can contribute to the 'erosion of Indigenous culture and knowledge'.

Nevertheless, there do not seem to be any significant standardised pathways from school to Wānanga programmes.

4.5 Ministry Analysis of Secondary–Tertiary Pathways

The Ministry undertook analysis of data from government educational agencies to ascertain if there were significant volumes of students achieving credits in the same Technology subjects at school, and then moving to the same tertiary qualification. This would identify secondary–tertiary pathways as defined in Section 14.1. The Ministry reported these results directly to the Panel.

The first stage of the analysis grouped students studying Technology in 2009–2018 into three groups: those taking at least 14 credits in Digital Technology and its predecessors, DVC and other Technologies. Within the three broad groupings, students could then be further divided into those who were assessed via unit standards and those assessed via achievement standards. The Panel acknowledges that there could be students undertaking mixed programmes of 14 or more credits who may not be included under these definitions.

The study then looked at what tertiary programmes (if any) students enrolled for in the subsequent two years. Overall, the results showed that students who completed Technology achievement standards at school moved to a very wide range of tertiary options, with limited channelling into particular pathways.

For the Digital Technology grouping, about 11% enrolled in tertiary study in the same field; 11% in engineering; 17% in management and commerce; and 29% in mixed programmes. About one quarter had not enrolled for tertiary study.

For the DVC grouping, 31% enrolled in architecture and creative arts (a strong correlation); 11% in engineering and related technologies; 7% in management and commerce; and 24% in mixed programmes. 22% had not enrolled for tertiary study.

For the CMT/PT/generic Technology grouping, 13% enrolled in architecture and the creative arts; 14% in management and commerce; 8% in engineering; and 7% in information technology.

For those progressing to tertiary study in engineering and related technologies, the highest correlation was (as expected) with the study of maths and physics, with only about 10% of those studying any form of Technology progressing to engineering. Studying maths and physics was roughly twice as predictive of choosing engineering.

In the second stage of the analysis, using the 2014–2018 data subset, the Ministry sought to better include students with mixed Technology programmes. If a student took at least 14 credits

[63] Sweet Analytics. (n.d.). *Additional BCATS outcomes.* https://sweetanalytics.co.nz/content/additional-bcats-outcomes/

[64] Sweet Analytics. (n.d.). *Evaluating the mechanical engineering gateway.* https://sweetanalytics.co.nz/content/evaluating-mechanical-engineering-gateway/

[65] Sweet Analytics. (n.d.). *Evaluating the mechanical electrotechnology gateway.* https://sweetanalytics.co.nz/content/evaluating-electrotechnology-gateway/

[66] Resta, P. (2011). *ICTs and indigenous people.* Policy brief to UNESCO Institute for Information Technologies in Education. Moscow, Russian Federation: UNESCO Institute.

[67] Dei, G. (2016). Conceptualizing Indigeneity and the Implications for Indigenous research and African development. *Confluence: Journal of World Philosophies, 2,* 52–79.

[68] Wolfgramm, T. (2014). *[Re]Claiming our technological sovereignty through co-creating the Māori innovation, New Technology, & ICT Sector* [Position Paper]. Presented by Māori Innovation & New Technology (MINT) Cooperative, Manukura, Planet Māori. http://planetmaori.com/Files/Content/2015/Re-Claiming_our_Technological_Sovereignty_-_Paper_-_Tania_Wolfgramm_2014.pdf

in Technology, and of those at least half were in a specific subject, then the student was classified accordingly. Further, it was investigated whether there was an association between the use of unit standards or achievement standards, and tertiary qualification. The key findings related to pathways from this second stage analysis were:

- The higher the Level at which a student studied Technology at school the more likely they were to enrol in a technology-rich tertiary qualification (that is, architecture, design and creative arts, engineering and related technologies, and information technology). While the number of students at Level 2 was only about half, and those at Level 3 only about one-third of the students at Level 1, the proportion going to technology-rich tertiary study rose from about 40% at Level 1 to about 60% at Level 3.
- Students who had studied DVC at school were highly likely to progress into degree-level tertiary study in architecture, design and creative arts.
- A group of students in the CMT strand (Construction & Mechanical Technologies, which includes using achievement standards assessing parts of technological practice using textiles as materials) progressed to tertiary study in architecture, design and creative arts. The Panel considered it likely that these students had been studying mixed programmes drawing from DVC, generic Technology standards and the textile materials standards.
- There was significant progression from Digital Technology at school to engineering and related technologies or information technology programmes in the tertiary sector, with an almost even split between these two tertiary areas. A lower but still significant number who studied Digital Technology progressed to tertiary study in architecture, design and the creative arts.
- If a student progressed to Level 3 and was assessed using achievement standards at school, they were far more likely to progress to degree-level rather than sub-degree tertiary study.
- Those students taking unit standards at school were likely to progress to sub-degree tertiary study.

Overall, the meta-analysis reinforces the earlier evidence, as well as identifying one further pathway of students into the architecture, design and creative fields: from school Technology programmes using the textile material achievement standards.

4.6 Summary

Standardisation and a significant number of students taking substantially equivalent programmes at different schools are the basis for establishing secondary–tertiary pathways.

There is some progression from DVC and the textile-rich achievement standards to degree-level design studies, and some benefits from successful study in Digital Technology for those looking to progress to polytechnic Level 6 and above qualifications in ICT or engineering. Otherwise, there is little evidence of pathways from success in Technology to Level 6 and above qualifications, which in the Panel's view is not unexpected given the plethora of standards and differing approaches by schools.

Where a tertiary provider such as an ITO has provided a unit standard-based programme delivered to senior high school students, some valuable and worthwhile pathways to Level 5 and below qualifications on the NZQF have been created. This was reinforced through the meta-study.

Nevertheless, the evidence is that the primary benefit of successful study in Technology is not progression along a specialised pathway – it is improved technological literacy and the independent learning skills developed through student-led, innovative technological practice. As initially envisaged when the Technology learning area was created, it is a learning area that is beneficial to all, irrespective of whether or not students continue in a technology-rich field at tertiary level. When students are provided with opportunities to develop a deep and broad technological literacy, they are equipped to participate in society as informed citizens, who can make discerning decisions about the technologies they choose to interact with or not.[69]

Wāhanga Tuarima

5. Employer Perspectives

The Panel observed that most successful businesses rely on their own in-house body of knowledge that underpins their competitive advantage as a business. For every business, this body of knowledge is unique. In contrast, the body of knowledge as delivered in schools, and even tertiary providers, can only partly overlap with the knowledge inherent in a specific business. All employers need to induct their employees so that they quickly learn the relevant employer-specific knowledge. Schools assist employers when they deliver broad literacy, numeracy and independent learning skills, and relevant tertiary study can give the employee a head start in gaining specialised knowledge important to the business. If that tertiary study is partly workplace-based (for example, an apprenticeship) then theory and practice are more closely knitted, but tertiary qualifications at Levels 6 and above generally provide a broad-based rather than a very specific body of knowledge.

As an example of employer views, in its submission to the 2018 review of NCEA, the peak business organisation, Business New Zealand,[70] outlined that employers wanted NCEA to ensure students had core foundational skills:

> Young people [should] have literacy and numeracy levels that enable them to undertake further learning and employability skills (such as communication, problem solving, teamwork, self-management, resilience and a positive attitude), and the confidence in their developed skills to navigate successfully to employment or further education or training.

This has been a consistent message from employers globally. For example, the World Economic Forum[71] lists the top desirable skills in 2020 as including complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgement and decision making, service orientation, negotiation and cognitive flexibility. Technology education is very well aligned, arguably better than many other learning areas, for contributing to the development of these skills.

[69] Ministry of Education. (2007). *The New Zealand curriculum.* Wellington, NZ: Learning Media.

[70] BusinessNZ. (2018). *NCEA—Have your say.* https://www.businessnz.org.nz/__data/assets/pdf_file/0011/156278/181019-BusinessNZ-NCEA-Opportunities.pdf

[71] World Economic Forum. (2020). *The future of jobs report.* http://www3.weforum.org/docs/WEF_Future_of_Jobs_2020.pdf

Employers are keen to support education in their communities. There are many examples where an employer has supported a school by providing equipment and real-world problems on which students can work. This support means that a school can develop a customised programme of learning, taking advantage of the enriched learning environments. This may assist in preparing students for assessment. It may also motivate students to plan careers in the industry from which the employer comes. The example of the support of a local engineering firm at Hastings Boys' High School[72] is simply one of many.

Generally, with their restricted budgets, schools have equipment that can be several generations behind what industry presently uses. Industry support allows students access to more modern equipment, but most school education will continue using outmoded equipment. Hence, school education should use specific contexts and learning to reinforce principles, rather than focus on the specific for its own sake. In other words, the focus of knowledge taught in technology should be on transferable conceptual and procedural knowledge.[73, 74]

The Panel's view is that it is important not to confuse the role of employers in providing locally relevant, rich learning environments to support programmes of learning, with the creation of successful pathways to employment; such pathways will generally require successful post-secondary study. Where an employer takes on someone from school, that employer will often partner with the employee so that their tertiary study and employment go hand in hand. When employers look to employ graduates from the tertiary sector with what are perceived to be relevant bodies of knowledge, the assumption is that there will be reduced time and cost required for that employee to become proficient in the employer's own internal know-how.

Overall, the benefits to employers of a prospective employee having succeeded in school Technology programmes are that they possess a broad technological literacy and exhibit knowledge and skills in undertaking innovative technological practice, rather than holding a specific set of skills or knowledge. When school Technology is delivered well, students grow their independent learning skills and transferable knowledge base, which is beneficial to employers.

Wāhanga Tuaono

6. Summary of the Emerging Evidence Base

The Panel's findings presented thus far are:

- The two big ideas of the technology curriculum are still valid – all students need sufficient technological literacy to live dignified and full lives as citizens of Aotearoa New Zealand (that is, they are able to educate and re-educate themselves and make discerning choices faced with an ever-changing array of future technologies); and will benefit from undertaking technological practice – a purposeful, knowledge-rich process of working out practical and innovative ways to meet needs, address an issue or respond to an opportunity.
- Successful broad-based multi-disciplinary learning in the Technology learning area is highly beneficial to students, irrespective of their future career pathway.
- Technology from a Māori perspective is not limited to traditional arts and sciences, but is adapting and evolving to be relevant to the place and space it is situated in. However, it exists within the cultural values and tikanga that provide a structure of safety and ethical consideration.

- Progression in Technology largely arises from accumulating greater conceptual and procedural knowledge to be able to tackle increasingly complex issues, through undertaking increasing challenging technological activities.
- Employers and many tertiary providers attach greater weight to strong 'basics' like literacy (including technological literacy) and numeracy than they do to school subject specialisations in Technology.
- Digital technological literacy has been shown to assist students to succeed when studying in Wānanga.
- A precondition of secondary–tertiary pathways is sufficient standardisation; that is, a reasonably sized student cohort at many different schools taking and being assessed in learning programmes with substantially equivalent (but not necessarily identical) components. Pathways without student volume are an unrealistic prospect.
- There is little evidence of the existence of pathways to Level 6 (on the NZQF) and above study, enabled though success in passing achievement standards from the Technology learning area, other than from DVC to architecture, design and creative arts; from DT to ICT; and from the textile materials achievement standards to some specialisations in design.
- Pathways to Levels 3–5 on the NZQF may have been assisted by tertiary-led programmes developed in the light of skill shortages by Industry Training Organisations for delivery in schools as a primer to encourage students to take up those qualifications, for example, BCATS.
- The existing proliferation of achievement standards for Technology, and the presence of specialisations within the Technology learning area has been inadvertently counter-productive through encouraging over-early specialisation, cutting off rather than enabling pathways and enabling teachers to present assessment programmes that are not reflective of all the aims of *The New Zealand Curriculum*.
- Given the large number of students who move in and out of Technology between years 11 and 12 and years 12 and 13, there is little evidence that there are career-driving, motivational benefits to students from providing specialisation within Technology.
- There is little demonstrated actual benefit to students of subject specialisation in Technology in Years 11 to 13; while this is claimed to be in the interest of students, specialisation seems to be related to maintaining the subject divisions that existed in pre-1995 technical education.
- The evidence indicates that the long-term interests of students will be better met by a sound and broad base of technological literacy, and skills in knowledge-rich technological practice, than by early specialisation of subjects assessed by a select group of achievement standards that do not cover all three strands of the Technology learning area. The sound base would also build the independent learning skills employers desire.
- To the extent that pathways might be able to exist with sufficient volume of students from multiple schools, and address tertiary programme and employer needs, they are more likely to arise from top-down (tertiary-led) rather than bottom-up (school-led) programmes.

[72] HBHS Technology Initiative. (n.d.). *Paton Engineering Ltd.* https://www.hastingsboystechnology.co.nz/patton-engineering

[73] Jones, A. T. (2009). Towards an articulation of student making progress in learning technological concepts and processes. In A. T. Jones & M. J. de Vries (Eds.), *International handbook of research and development in technology education* (pp. 93–104). Rotterdam, Netherlands: Sense.

[74] Harwood, C. D. (2014). *Enhancing student decision making in technological practice* [Unpublished doctoral thesis]. Massey University, New Zealand.

Wāhanga Tuawhitu

7. The 2019/2021 NCEA Reforms

7.1 Impacts for Technology: Level 1

The 2019/2021 reforms of the NCEA include goals to better support student learning and boost their chances of successful transfer into tertiary study via pathways. The proposal approved by Cabinet was to retain Digital Technology and Design & Visual Communication, to integrate the generic Technology standards through new Technology subjects, and to pass parts of Processing Technologies to Food Science, which was to replace Home Economics in the Health and Physical Education learning area. Construction & Mechanical Technologies and the remaining part of Processing Technologies were to be grouped within a subject for which the title was still to be established, but something like Materials and Processing Technologies.

The Panel was given the opportunity to comment, but only in so far as the design of the new subjects was concerned. It provided initial commentary to the Ministry in January 2021, which it has since refined as set out here:

> Assessment in Technology at Level 1 should be based around the New Zealand Curriculum's big ideas of technological literacy, and technology as a purposeful and innovative activity that draws from a variety of knowledge bases to meet needs, address issues or respond to opportunities. The Panel is of the view that at Level 1, there is little educational justification for splitting into multiple subjects. Greatest student benefits would accrue by assessment in a multi-disciplinary (multi-domain) single subject, assessed across all the major elements of the Technology learning area.
>
> Nevertheless, if there are to be three subjects, the Panel proposes that a curriculum-true and educationally sound set of three subjects, reasonably well-matched to student interests, can be described as follows:
>
> **Digital Technology:** Applying computational thinking and creating digital outcomes.
>
> **Design in Technology:** Exploring feasible spatial and product designs by modelling and drawing.
>
> **Development in Technology:** Making fit-for-purpose products, artefacts, devices or outcomes.
>
> Each subject has a working title and an explanatory 'by-line' to inform parents and students about the purpose of the subject. Each should also have a description of about 100 words to assist teachers. It is vital that the explanatory by-line is widely used, as it is that rather than the working title that clarifies the distinctions between the subjects.
>
> - **Digital Technology** has developed its own pathway, trajectory and distinctiveness, recognising the global significance of the ICT industry. The existence of **Digital Technology** must not preclude the extensive use of digital technologies in the other subjects.
> - **Design in Technology** is firmly anchored in the Technology learning area, finally dealing with a confusing legacy issue by excluding 'visual communication', which is not distinct to Technology. The explanatory by-line sets out the essential elements of this subject.

- **Development in Technology** differs from Design in Technology through its focus on making fit-for-purpose products, artefacts, devices or outcomes, rather than exploring designs through modelling and drawing. **Development in Technology** can be delivered in a variety of learning contexts, not necessarily involving material use or processing, and ideally should not be constrained – Technology education is richest when multi-disciplinary.

In terms of the subject working titles, the Panel recognises that words like development and design are widely applied across the Technology learning area, but considers that with the explanatory by-lines, each subject would soon be widely understood. The explanatory by-lines give meaning to the brief subject titles and are intended to assist student decision making and parent understanding. It is vital that the explanatory by-lines are widely communicated.

In each of the subjects, the achievement standards must cover the Nature of Technology, broad-based conceptual and procedural Technological Knowledge, and Technological Practice to ensure that students' technological literacy is assessed.

In **Development in Technology**, students should be able to demonstrate that they can access and use relevant domain-specific technological knowledge, for example, to select and apply suitable materials, techniques and processes when making technological products.

A common achievement standard across all three subjects to assess the Nature of Technology would be beneficial to ensure that all students consider how technologies of various types interact with society, values and culture. Similarly, a common achievement standard would be beneficial for Technological Knowledge, where the student conceptual understandings are assessed.

The credit values attached to achievement standards are also important for the writers to consider. Past experiences in attributing too many credits and assessing too broad a range of knowledge and/or competence within the one assessment standard led to students failing to be awarded standards.[75]

Assessment in Hangarau and Hangarau Matihiko should continue to recognise the holistic approach to technological practice in te ao Māori.

7.2 Impacts for Technology: Levels 2 and 3

The Ministry invited the Panel the opportunity to comment on Technology subjects at Levels 2 and 3, with particular reference to what level of specialisation can be justified. This question can be re-phrased as asking: To what extent is there evidence to warrant the creation of subjects beyond the three subjects that have been foreshadowed at Level 1?

As set out above, the views presented in favour of more specialisation are generally to better match the expressed interests of schools, teachers and students; and to progress students on pathways to employment and/or tertiary study. However, the evidence suggests this may prejudice rather than support the long-term interests of students. In contrast, broad-based technology education has significant benefits.

[75] Compton, V. J. & Harwood, C .D. (2004). Technology education achievement standards: Are they fit for the purpose? In *3rd Biennial International Conference on Technology Education Research. Learning for Innovation in Technology Education* (pp. 140–149).

In this light, the Panel offers the following commentary on the assumption that there will be three subjects at Level 1, and that these will be aligned to the Panel's earlier comments.

7.2.1 Digital Technology: Applying computational thinking and creating digital outcomes

There is a sufficient basis for continuing Digital Technology at Levels 2 and 3. The relevant curriculum for Digital Technology ranges from some theoretical underpinnings in applying computational thinking, through to practical applications. For students seeking to progress to ICT study at levels 3–7 in the polytechnic system, this is appropriate – a broad rather than narrow pathway would be suitable for such students.

Students wanting to follow a more theoretical route (computational thinking) than an applications route (creating digital outcomes) would be better catered for by introducing 'Computer Science' as a new subject in the mathematics learning area at Levels 2 and 3. This subject has an established and rich global body of knowledge. The Technology staircase model suggests that its presence as an enabling subject in the mathematics learning area would enable students likely to study ICT at university at levels 7 and above to obtain real benefit. Computer science in mathematics can co-exist with a continuation of applied computational thinking in Digital Technology.

Given it has been established that the benefits of studying Technology at senior high school are greatest if the students undertake a broad-based rather than narrow programme of learning, the Panel does not consider there is justification for Digital Technology at Levels 2 and 3 to be further specialised by splitting into more than one subject. However, some in-subject flexibility should be contemplated (see 7.2.4 below).

7.2.2 Design in Technology: Exploring feasible product and spatial designs through modelling and drawing

The predecessor of Design in Technology, DVC, has been a single subject for many years, and there is some pathway benefit from the existence of such a subject. However, presentation is currently over-emphasised. To cover the Technology curriculum, some generic Technology achievement standards need to be taken to allow students to demonstrate their understandings and competence in technological literacy.

For the future, and in the light of the evidence that favours broad rather than narrow programmes of learning in the Technology learning area, it is difficult to justify more than a single Design subject. While it is vitally important that the assessment at Levels 2 and 3 is comprehensive across the Technology learning area, some in-subject flexibility could be contemplated (see 7.2.4 below). Such flexibility should not be used for further assessment of presentation skills, particularly those used when modelling is through using computer applications.

7.2.3 Development in Technology: Making fit-for-purpose products, artefacts, devices or outcomes

The Panel recognises that a single 'Development in Technology' subject would be a consolidation of what is presently delivered in many schools, but there is little evidence that existing specialisation has supported secondary–tertiary pathways. Other mechanisms have been identified as better for assisting such pathways.

The benefit to students of multi-disciplinary learning, and drawing on a range of materials, techniques and processes is significant. As set out above, there is also little evidence that schools have actually been delivering knowledge-rich Technology education specific to a specialisation. Rather, schools have tended to offer students subjects packaged solely as different contexts in which technological practice has been taught and assessed. Although not necessarily desirable to do so, the achievement standards in Development in Technology can be designed to accommodate this type of school practice. This approach would also support the continuation of a pathway from textile-rich programmes at school to tertiary study in design. However, the assessment of knowledge should be targeted to the broader, transferable conceptual and procedural knowledge that research has shown is more beneficial to students than domain-specific knowledge.

In Development in Technology in particular, it is vital that there is a reversal of what appears to be a common classroom pedagogy. Technological practice must be 'led' from the need, issue and opportunity (which practice may then select from a wide range of available materials and techniques), rather than 'pushed' from a desire to apply particular materials and techniques.

Some in-subject flexibility could be contemplated (see 7.2.4 below).

7.2.4 Opportunities for Flexibility

If the three subjects are retained at Levels 2 and 3, and no additional subjects are added, there may be value in allowing more in-subject choice of standards by increasing the credits available from 20 to either 24 or 25. This would allow an extra achievement standard to be included, but still require students who seek to achieve 14 credits to be assessed across all strands of the Technology curriculum area. At a practical level, an extra standard might support schools to deliver learning programmes drawing on local opportunities for students to work on real-world problems important to their community, mana whenua, local employers or the local environment.

Introducing an extra standard at Levels 2 and 3 would represent a compromise between the evidence that the long-term interests of students do not really require such specialisation, and the motivational benefits that may arise if students and teachers have the flexibility to take up local real-world opportunities.

7.2.5 Assessment of Technological Knowledge

Assessment of technological knowledge needs to recognise the ability of the student to access, comprehend and apply increasingly complex bodies of knowledge relevant to their practice, rather than just domain-specific knowledge. In order to be able to do this across multiple contexts, students need broad-based knowledge of technological concepts. For example, in order to select an appropriate material for use in a specific application, students need to know that it is a material's properties that allow it to be manipulated and/or transformed. Being aware of such concepts allows them to consider a range of materials and determine which is a 'best/a likely fit' for the application needed. Knowing (through assessment) that students possess conceptual and procedural understanding rather than solely discrete bodies of specialist knowledge ensures that students have the understandings to work across multiple contexts and tackle increasingly challenging technological activities.

7.3 Impacts for Technology: Scholarship

Historically, scholarship in Technology has been assessed holistically with a focus on assessing students' overall technological literacy. To be consistent with the other recommendations of the Panel, it is recommended that this practice continue.

7.4 Localisation

Design of the NCEA achievement standards should enable schools to take advantage of local community, employer or mana whenua support, and any other local circumstances to create customised learning programmes that are meaningful locally, but suitable to prepare students for broad-based NCEA achievement standard assessment. Opportunities for students to develop critical understanding of technology from a cultural perspective are particularly valuable and should be supported.

7.5 Pathways to Tertiary Study

The Panel considers that the broad benefits to school students of success across the Technology curriculum outweigh specific benefits for students seeking to progress in specific Technology subjects. Worse, by narrowing programmes of learning, ostensibly to support specific secondary–tertiary pathways, there is a risk of perpetuating the highly undesirable two stream system: academic and vocational. Hence, the Panel would prefer secondary–tertiary pathways to be de-emphasised, including discontinuing the two awards (University Entrance and the proposed Vocational Entrance) that lead to streaming within schools. Tertiary providers are well able to assess whether a student's prior achievement gives them a reasonable chance of success in a particular tertiary programme. It is inappropriate for schools to pre-determine tertiary destinations for students by streaming.

Nevertheless, the Panel accepts there are students whose educational needs are best met by a combined secondary/tertiary programme of learning. For example, for many years some Year 13 students have concurrently taken university papers. While tertiary providers and industry have significant contributions to make when designing combined secondary/tertiary programmes, it is also recognised by the Panel that these organisations have historically focused on meeting their own recruitment needs. This may not aid students gaining broad-based technological literacy or keeping a range of career pathways open. Further, students engaging in vocationally focused Technology programmes with external providers are often out of school for one day per week, which can be disruptive.

In the recently changed vocational education environment, it would seem sensible for a coherent programme of work between the Workforce Development Councils and the Ministry to co-create and then support a small number of relatively standardised 'subjects' that contain content the Councils see as supportive of student progression towards Levels 3–5 qualifications, that the Ministry ensures are curriculum-true and that schools can deliver with suitable support. Students whose career aspirations are towards Level 3–5 qualifications could undertake a hybrid programme including one or two such subjects. If the delivery can be in the school, this will cause less disruption at a practical level.

[76] Reinsfield, E., & Lee, K. (2021). Exploring the technology teacher shortage in New Zealand: The implications for quality teaching and learning. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-021-09668-4

Wāhanga Tuawaru

8. The Technology Teaching Workforce

The Panel recognises that the changes it proposes will not be effective unless the Technology teaching workforce is supported and developed. Both pre-service and in-service professional development will be needed. Indeed, a strength of the changes through the 2000s was Ministry support for teacher professional learning (see Section 9) – and yet still the changes were not uniformly adopted across Aotearoa, nor were they adopted at the same speed.

The Panel also recognises that many Technology teachers enter the teaching workforce after considerable experience in other occupational roles. For them to succeed as teachers and have satisfying, appropriately rewarded careers as Technology teachers, the Ministry needs to ensure there are not inadvertent impediments to entrants to teaching from such backgrounds. Recently, Technology Education NZ (TENZ) explored the current Technology teacher shortage, noting that many schools have experienced difficulty attracting qualified technology teachers. To address this issue, "non-specialist teachers are being used from other learning areas. Schools have had to adapt their learning programmes to suit the teachers' knowledge and skills, rather than be responsive and adaptive to their students' learning needs or interests."[76]

The Panel recognises there is a growing awareness of the potential of emerging digital technologies to contribute to discriminatory practices and systems. Professional development in both the Technology and Hangarau spaces needs to incorporate an understanding of this, as well as allowing for strategies to apply critically conscious decision making to the understanding and use of technology.

Wāhanga Tuaiwa

9. Key Findings

Aotearoa New Zealand has a world-leading curriculum in the Technology learning area. Published research from the two decades following the inception of the curriculum in the early 1990s referred to in this report shows that there are clear benefits to all students of successful study in the Technology learning area. The two big ideas – technological literacy as an enabler for people to live a dignified and successful life in the face of ever-changing technology, and multi-disciplinary, purposeful, innovative knowledge-rich practice – continue to be as relevant to the needs and aspirations of this country as they were 30 years ago. Broad-based 'Technology education for all' is aligned to Aotearoa New Zealand's goal to be a nation of world leading innovators.

That evidence indicates that the potential benefits of the curriculum are realised when teachers have sufficient professional development and support. In the more recent absence of that support, there has been a discernible drift back to technical education, with this being inadvertently supported by an overly permissive NCEA assessment matrix that allows students to obtain 14 credits without really achieving proficiency aligned to the big ideas of the Technology learning area. It is in the long-term interests of all New Zealanders for there to be adequate delivery and assessment of the Technology curriculum.

Further, the learning for all students in Aotearoa New Zealand will be enrichened if it draws as much on Mātauranga Māori as on knowledge derived from 'western' science, and on methods from kaupapa Māori, such as rangahau, as well as from technological practices framed in the western world. Technology in this country needs to be firmly embedded in the cultural and social contexts of a nation fully implementing the key principles of Te Tiriti o Waitangi. Although relatively few in number, students studying Hangarau and Hangarau Matihiko need as much consideration as other Technology students. Often, directly translating English to Māori does not capture the depth and understanding of space and place required in te ao Māori. The Panel considers there needs to be alignment between both the Technology Curriculum and the Hangarau Curriculum, with enough scope for Māori Medium and bilingual schools to create learning that incorporates a Māori world view. Given that 90% of Māori students are in mainstream, English-medium education, skills to adapt teaching and learning to incorporate Māori and Indigenous world views, including expanding the methods of evidencing knowledge, need to be included across the board.

The opportunity to re-develop the Technology assessment matrix provides the Ministry with a unique opportunity to re-align what students study in senior high school with the Technology curriculum. The educational benefits are so great that the Panel considers this must be done. The Panel recognises this will require that pedagogy and assessment be strongly linked back to the foundations of the curriculum. Suitable support will be needed to enable schools and teachers to implement these changes at a deep rather than surface level.

Although well-intended, opportunities for specialisation and attempts to promote secondary–tertiary pathways have proven counter-productive – at worst, restricting rather than enabling the learning journeys of some students. The long-term benefits of students studying Technology will be best realised by a 'thin-walled' rather than 'thick-walled' approach to subjects, with cross-linking and multi-disciplinary approaches. In this context, the Panel recommends restricting the number of subjects in the Technology learning area to no more than three at each of Levels 1, 2 and 3, continuing to emphasise a broad-based technological literacy and a focus on innovative technological practice to meet needs, address issues or take advantage of opportunities.

The three proposed subjects should be supported with clear explanatory by-lines that clearly communicate their purpose. The proposed names for the three subjects are:

Digital Technology: Applying computational thinking and creating digital outcomes.
Design in Technology: Exploring feasible spatial and product designs by modelling and drawing.
Development in Technology: Making fit-for-purpose products, artefacts, devices or outcomes.

In each of the three proposed subjects, the achievement standards must cover the Nature of Technology, broad-based conceptual and procedural Technological Knowledge, and Technological Practice to ensure students' technological literacy is assessed.

In Development in Technology, students should be able to demonstrate that they can access and use relevant domain-specific technological knowledge, for example, to select and apply suitable materials, techniques and processes when making technological products.

To avoid perpetuation of the highly undesirable two stream system in schools – academic and vocational – it would be desirable to discontinue the two awards (University Entrance and the proposed Vocational Entrance), which end up being signposts to pre-determined tertiary destinations. Tertiary providers are well able to assess whether a student's prior achievement gives them a reasonable chance of success in a particular tertiary programme.

To support students whose educational needs are best met by a combined secondary/tertiary programme of learning, a coherent work programme is needed between the Workforce Development Councils (previously Industry Training Organisations) and the Ministry. It would be sensible for the Ministry to co-create a small number of relatively standardised 'subjects' (for schools to deliver) that contain content the Councils see as supportive of student progression towards Levels 3–5 qualifications. This would sit beside the opportunity for other school students to undertake some university study.

The Panel greatly appreciates the opportunity to provide its views to the Ministry on what is an important part of the Curriculum.

Appendix 1 – Short Panel Member Biographies

Professor Alister Jones (chair)

Alister is currently the Senior Deputy Vice-Chancellor at University of Waikato. He is a former Dean of Education and was previously Research Professor and Director of the Wilf Malcolm Institute of Educational Research. Alister has managed and directed research projects that have informed policy, curriculum and teacher development in New Zealand and internationally, and was previously a council member of Royal Society Te Apārangi.

Dr Andrew Cleland FRSNZ

Andrew holds a BTech and a PhD in Food Engineering from Massey University. From 1978 to 2000, Andrew held academic roles in technology and engineering at Massey University, including several years as Programme Director for Technology and Engineering. From 2000 to 2014 Andrew was chief executive of the Institution of Professional Engineers New Zealand. Under his guidance, the Institution provided support to Technology Education New Zealand. From 2014 to early 2021, Andrew was chief executive of Royal Society Te Apārangi, with responsibility for the Society's legislated role to support science and technology education.

Angela Christie

Angela was amongst the first in-service Technology facilitators in Wellington in the mid-1990s and worked with the Institute of Professional Engineers New Zealand (IPENZ) to support the implementation and case studies of Technology in primary and secondary schools. Angela was a member of the government's Growth and Innovation Fund Technology Education Advisory Group which trialled new initiatives in pathways, and primary and secondary Technology.

Astrid Visser

Astrid is the Design Kaihāpai at the College of Creative Arts, Massey University. She is a creative education specialist and former secondary school teacher, who has been involved in secondary teacher professional learning for many years. She supports secondary educators through professional learning and manages discourse between the College of Creative Arts and secondary Visual Arts and Technology teachers and teacher associations.

Dr Cathy Buntting (special contributor)

Cathy is Director of the Wilf Malcolm Institute of Educational Research at the University of Waikato. Her research interests straddle science, technology and integrated STEM education research, and she has a strong commitment to the research-practice nexus. Cathy led the development of the Biotechnology Learning Hub in the 2000s and was a member of the technology achievement standards writing group in 2012. She has written extensively on the implementation of technology education in NZ.

Cheryl Pym

Cheryl has a MEd in Adult Teaching and Learning from Massey University and is an accredited professional learning facilitator with over 20 years' experience in Technology Education. Cheryl's has worked on curriculum design, development and assessment across all levels of schooling; developed materials to support teacher and learner development; and designed professional learning programmes and assessment across the Technology learning area. Cheryl has worked with NZQA and Ministry of Education on curriculum and assessment, including supporting expert panels, and is currently a Technology learning area expert on relevant advisory groups.

Dr Cliff Harwood

Cliff is Manager of External Relations and Qualifications at New Zealand Defence Force and has been closely involved with technology education in New Zealand since his days as Head of Faculty – Technology, at Awatapu College in Palmerston North. Cliff worked with Massey University to develop a Diploma of Technology Education and joined Massey University College of Education in 1996 where he led many classroom-based research projects that informed the development of Technology in the New Zealand Curriculum. Cliff also played a pivotal role in implementing technology into teachers' classrooms and developing national qualifications for technology in New Zealand, including in roles with Ministry of Education.

Kane Milne (Ngāi Tahu, Ngāti Māmoe)

Kane is the Lead for Innovation Hubs at Te Wānanga o Aotearoa and the winner of the Tertiary ICT Award for Excellence in Technology for Learning Research or Students. Kane has a Masters in Applied Indigenous Knowledge that was based on his work at Te Wānanga o Aotearoa and the Te Toiotua innovation initiative.

Mary-Claire Proctor

Mary-Claire is the Head of School, IT and Business at the Wellington Institute of Technology and Whitireia Community Polytechnic. She has 19 years' experience in the tertiary education sector across Institute of Technology and Polytechnic (ITP), University and College of Education environments, initially as an Information Technology Educator and then in various management roles. Mary-Claire is a former Chair and current member of the executive for Computing and Information Technology Research and Education NZ and serves as a member of the IT Professionals NZ Degree Accreditation Board.

Whakapā mai
Connect with us

RoyalSocietyNZ
@royalsocietynz
royalsociety.org.nz
royalsocietynz

11 Turnbull Street,
Thorndon, Wellington 6011
PO Box 598, Wellington 6140,
New Zealand

Email info@royalsociety.org.nz

Print ISBN 978-1-877317-49-1
Digital ISBN 978-1-877317-50-7

ROYAL SOCIETY TE APĀRANGI