Consultant Report
Securing Australia's Future
STEM: Country Comparisons

This report can be found at www.acola.org.au

STEM initiatives and issues in New Zealand

Dr Cathy Buntting, University of Waikato
Professor Alister Jones, University of Waikato
Professor Liz McKinley, University of Auckland
Dr Mark Gan, University of Auckland

Table of contents

Executive summary

This report considers initiatives in New Zealand to enhance STEM education across the education sector. Important within this consideration is an exploration of initiatives to increase the engagement and achievement of Māori students. As the indigenous people of New Zealand, Māori have particular statutory rights under the Treaty of Waitangi. Māori also hold significant wealth as a result of Treaty settlements and subsequent investment. They are increasingly taking ownership of their own economic and social development. Te reo Māori, the Māori language, is recognised as an official language. Māori are fully integrated within New Zealand society and there is the option for them to attend English medium, bilingual, or kura kaupapa Māori (KKM) schools. The curriculum is published in both English and te reo Māori. Current education policy emphasises the importance of Māori succeeding as Māori.

The engagement and achievement of students with Pacific Island ancestry is also prioritised in education policy. Both Māori and Pasifika students tend to be under-represented in measures of academic achievement. They also represent growing populations, and increasing numbers will be entering the future workforce.

The importance of enhancing the education opportunities available to Māori and Pasifika peoples as well as others from low socioeconomic backgrounds is recognised in early childhood education (ECE) policy, and participation has been steadily increasing. This has been hugely influenced by the introduction of Government funding for early childhood education for all three and four year olds. The early childhood curriculum, Te Whariki, is bilingual and strongly bicultural.

The school curriculum framework operates from Years 1-13 and is designed to be sufficiently flexible for schools – which are self-governing – to develop programmes that reflect the needs and interests of their communities. Up until very recently there was no national testing until the senior secondary level. This changed in 2009 with the introduction of policy requiring primary and intermediate schools to report on their students' achievement against national standards in numeracy and literacy. This policy has been met with controversy, much of which remains unresolved. Of particular relevance to this report are the likely implications for the teaching of science and technology – which were already at risk of being undervalued in many primary schools. For instance, professional development funding has recently been channelled away from subject-specific areas towards literacy and numeracy.

At the secondary level, assessment reform and the introduction of the National Certificate in Educational Achievement (NCEA) in the 2000s opened up opportunities for schools to develop innovative and engaging science and technology programmes, although these opportunities have to date not been fully realised. This is for a variety of reasons, including teacher, school and community understandings of NCEA, traditional school structures and timetabling, and the conservative effect of University entrance criteria. Science tends not to be a favoured school subject at senior secondary level, with even fewer students choosing technology. The reasons for this are diverse, but for some students they relate to students' earlier experiences of school science and/or technology. While past research shows the value of effective subject-specific teacher professional development, current funding tends to focus on more generic professional development, for example, culturally responsible or ICT-related pedagogies in a general sense. The impact of these programmes on student achievement in STEM-related areas is largely unknown. In addition, the impact of STEM-specific teacher professional development or resourcing has not tended to be substantively evaluated.

At the tertiary level, funding for science and engineering courses has slightly increased for 2013 although there appears to have been less consideration related to recruiting students into these fields, and retaining qualified professionals in New Zealand.

In general, there appears to be little cohesion and coherence across policies related to STEM education and uptake. In a small country where the vast majority of education initiatives are Government funded, this appears to be an opportunity that has been lost. On a more positive note, there are signs that the report on science education released by the Prime Minister's Chief Science Advisor (Gluckman, 2011) may be leading to increased cross-Governmental conversation in this area.

Introduction

This report contributes to one of six larger projects commissioned by the Australian Government to enhance national performance in the STEM (science, technology, engineering and mathematics) disciplines. Within this greater goal, this particular project seeks to identify and learn from initiatives implemented by other countries to increase the number of students studying STEM programmes at school and tertiary level. The focus is therefore on STEM in terms of human learning, knowledge and skills ('human capital'), and their applications in work. It does not concern the research, development and innovation system, except in relation to the training of knowledge workers.

The report addresses the following areas:

1. The New Zealand context

   This section sets our relevant background in relation to New Zealand's ethnic diversity including the rights of Māori in the country's policy frameworks; the structure of the education system; New Zealand's school qualifications and assessment framework; and an overview of qualification and employment rates for our different ethnic groups.

2. Attitudes to STEM

   This section includes the role and importance of STEM in the eyes of government, educational institutions, employers, community and media, families and students. This spans from the formal policy narratives about the role of STEM in economic development and innovation, to the cultural factors and practical drivers affecting attitudes to STEM in the minds of young people.

3. Patterns in school STEM achievement and provision

   The first part of this section offers an analysis of New Zealand students' achievement in science and mathematics according to TIMSS and PISA, and describes the assessment systems available at the national level, including the National Education Monitoring Project (NEMP), Assessment Resource Banks (ARBs), and the National Certificate in Educational Attainment (NCEA). In the second part, commentary is provided about teacher education and professional development and school employment of STEM teachers, and initiatives linking schools with the scientific/technological community.

4. STEM uptake at the tertiary level

   This section focuses on STEM uptake at the tertiary level and includes reference to university outreach and support programmes.

5. Uses of STEM beyond education

   This section reports on labour market uptake of STEM skills and knowledge, as well as questions of shortage and oversupply of STEM-related human capital in New

Zealand. Because of the absence of a national collection of data related to this area, this section was the most difficult to populate.

6. Strategies, policies and programmes used to enhance STEM

   This section summarises the policies, strategies, and programmes referred to in the previous sections to enhance STEM at all levels of education, particularly at school.

Definition of STEM

STEM is defined within the broader project that this report contributes to as learning and/or work in the fields of Science, Technology, Engineering and Mathematics, including learning at lower levels of compulsory schooling prior to entry into the specific disciplines at senior secondary and tertiary level. In this report, STEM includes natural and physical sciences (including mathematics), engineering, information technology, health (including veterinary sciences), architecture, and agricultural and environmental and related studies. These categories are used in the annual collation of national education data at the tertiary level. At the school level, STEM is described in the New Zealand Curriculum (Ministry of Education, 2007) within three discrete learning areas: science, technology and mathematics. Schools have responsibility for developing and implementing their own school-based curricula from these national documents.

The Aotearoa New Zealand context

Demographic context

New Zealand's population has rapidly become more ethnically diverse over the last two decades with significant increases in immigration from Asian countries (particularly China), South Africa, Britain, the Pacific Islands and India. Despite this range of nationalities NZ education tracks four 'ethnic' groups identified as: NZ European/Pākehā (including those who self-identify as 'New Zealanders'); Māori (the indigenous population); Pacific Island peoples, or Pasifika (a category that includes people who identify as descendants of Pacific Island nation states); and Asian (a category that groups people from a wide range of Asian countries, including India, and includes those born in New Zealand as well as those who have immigrated here). There is one further category identified as 'Other', which refers to a number of nationalities that do not easily sit in the categories identified, such as people who identify from Latin American and 'Middle Eastern' countries.

In June 2011 the nation's total population was estimated at 4,832,700, of which 3,312,200 (69%) were identified as NZ European/Pākehā; 674,200 (14%) as Māori; 345,000 (7%) as Pacific Island peoples or Pasifika; and 501,100 (10%) as Asian.[1] According to the 2006 census, 35% of Māori[2] and 38% of Pasifika were under 15, compared with 22% for the overall population[3]. These differing proportions of the total population have two major implications for this report. Firstly, larger numbers of Māori and Pasifika peoples will be entering the future workforce in greater proportions than previously encountered. With current underachievement rates of Māori and Pasifika students in STEM subjects, this demographic projection could be seen as posing a major risk to New Zealand's desire to be a knowledge economy. Secondly, this population proportion disparity, with a strong identity component, represents a uniqueness that should be considered to be an opportunity for STEM in New Zealand and not a

---

[1] http://wdmzpub01.stats.govt.nz/wds/TableViewer/tableView.aspx?ReportName=Population%20Projections/Projected%20Ethnic%20Population%20of%20New%20Zealand,%20by%20Age%20and%20Sex,%202006%20%28base%29%20-%202026%20Update

[2] Statistics New Zealand: Quickstats about Māori, see http://www.stats.govt.nz/Census/2006CensusHomePage/QuickStats/quickstats-about-a-subject/maori.aspx

[3] http://www.mpia.govt.nz/demographic-fact-sheet/

hindrance. The advantage of a youthful population structure is the potential economic contribution to be made in the context of a rapidly aging national workforce (Kukutai, 2011).

Today Māori are unequivocally an urban people and have been for many decades (Kukutai, 2011). This means that the Māori and NZ European/Pākehā populations are significantly integrated. It is important to note that Aotearoa New Zealand has no history of legislated segregated areas or reservations for tribes or groups, such as that found in Australia, the USA and Canada, and neither has it officially categorised its peoples in terms of 'quanta of blood' as found in other countries. However, it is fair to say ethnic identification is strong, which is mostly determined by the way the NZ Government identifies its population.

Political context

Māori are the indigenous people of Aotearoa (the Māori word for New Zealand), the tangata whenua (people of the land). The British colonisers were given the right to settlement in Aotearoa through the signing of the Treaty of Waitangi (ToW). The ToW is the founding document and was signed in 1840 between the British Crown[4] and over 500 Māori rangatira (chiefs). The ToW is a broad statement of principles relating to the governance of Aotearoa New Zealand. Importantly, it guarantees exclusive and undisturbed rights to Māori in terms of preservation of taonga (treasures), for example, land, fisheries, forest, language (Royal Commission on Social Policy, 1987, p. 4). It also gave Māori the rights and privileges of British subjects.

Race relations have not been completely harmonious. The protection of taonga has been and continues to be, albeit less so now, a contentious issue. These include issues of land confiscation and the Crown failing to meet their contractual promises and obligations to Māori upon sale of land by Māori. Investigating claims of Māori rights under the ToW is the exclusive domain of the Waitangi Tribunal, set up in 1986 and consisting of judiciary, academics, and iwi (tribal) and community leaders. The Waitangi Tribunal that makes recommendations – some of which are binding – to the New Zealand Government. More than 2000 claims have now been registered with the Tribunal, varying in size from claims on specific grievances by individual Māori up to comprehensive claims by one or more large iwi/hapu (tribal/family) groupings.[5]

The education system started to fail Māori students with the passing of the 1867 Native Schools Act, which marked the beginning of two educational milestones: first, the policy of using English as the sole medium of instruction, and secondly the beginning of a national education system for Māori (and before one for the British settlers children, which was still run at the provincial level). Many Māori at the time thought that learning the tongue of the British colonisers would lead to a more prosperous life. Schools became monocultural in language and curriculum when a national primary school curriculum was established in 1877. Consequently, by the 1970s Māori were in the unenviable position of not being able to speak te reo Māori (Māori language), and at the same time feeling limited in their educational attainments, partly as a result of assimilation policies.

Cultural and linguistic contexts

Data on the cultural aspects of Māori identity is sparse. The two traditional and symbolic markers are language and tribal/iwi affiliation. Before the turn of the 20th century the majority of Māori could speak their indigenous language but colonisation and

[4] New Zealand was granted limited self-government in the 1850s and by the late nineteenth century was a fully self-governing. In 1907, New Zealand became an independent Dominion and a fully independent nation in 1947, although in practice Britain had ceased to play any real role in the government of New Zealand much earlier than this.

[5] http://www.waitangi-tribunal.govt.nz/about/frequentlyaskedquestions.asp#4

consequent development of the nation convinced many Māori to place more importance on the learning and speaking of English. By the 1970s grave concerns were expressed by Māori educators about the survival of the language as there were now two to three generations who spoke only English. The loss of the language (and culture) was of concern as it resulted in a low self-esteem in Māori. This was and is still reflected in the statistics on crime, health, unemployment and educational achievement. For example, the majority of Māori students fail in science. While the proportion of Māori students taking science has risen over the years, their achievement in this subject is still well below their non-Māori counterparts. Such pass rates are similar for most subjects. The only subject that 'bucks the trend' in achievement is that of Māori language.

The loss of the language was also a concern in that, unlike other cultural groups in New Zealand, there was no other place in the world where the language would be preserved and developed. This situation is reflected in other parts of the world where indigenous peoples have been colonised and have become minorities in their own country, for example in Hawaii, Tahiti and North America. In response to this situation, Te Taura Whirl i te Reo Māori (The Māori Language Commission) was set up as a result of the Waitangi Tribunal's findings that the Māori language was a taonga (treasure) and had not been protected under the terms of the Treaty of Waitangi. Since the Māori language had not kept pace with the development of words with everyday use, as in other languages, Taura Whiri i te Reo Māori has the responsibility for developing all aspects of the language, including scientific vocabulary (Te Taura Whiri i te Reo Māori 1992) for use in school curricula and for other fora. This parallels developments in other countries such as Tahiti, Israel, Tanzania and Malaysia.

Aotearoa New Zealand has officially been a bilingual nation since 1987. Both Māori and English are official languages and either can be used, for example, in courts of law courts, addressing mail, writing a bank cheque, or presenting a doctoral thesis at a university. National early childhood and school curricula documents and support materials exist in both languages.

Although Māori has different dialects, these are not so disparate as to prevent communication between fluent speakers. It is worth noting that before New Zealand was colonised Māori lived in tribes or iwi. Each iwi has its own identity and culture. When the British settlers came Māori were labelled with the name Māori (meaning 'normal') and have since been grouped together as one entity by successive governments. All Māori speak English and only 23% speak te reo Māori (Kukutai, 2011). Few non-Māori speak Māori fluently, although many Māori words have been incorporated into New Zealand English such that there is a now a dictionary devoted to it (Keegan, 2012).

The other lynchpin of Māori identity and society is whakapapa or genealogical connections. These are often expressed in terms of iwi (tribe), hapū (sub-tribe) and whānau (extended family). Connectedness, to nature and people, is central to how Māori make sense of the world.

Economic context

In terms of this report, there is increasing political recognition of the potential contribution of Māori to economic development, both for their iwi and the country as a whole. For example, the Tainui and Ngāi Tahu peoples have significant economic holdings as a result of settlements under the Treaty of Waitangi. It is predicted that by 2020 post-settlement Māori investments will lead to new wealth, experience in economics, and expertise in financial governance and management. Iwi already own significant proportions of Sealords (NZ's largest fishing company), are the biggest forestry owners through Treelords and are significant landowners through the Ahuwhenua Trust. In other words, Māori have heavily invested in New Zealand's land and natural resource-based economy and will become major economic players.

With regards to STEM, currently Māori tend to gravitate to subjects with a 'human' element, for example, medical and environmental sciences rather than chemistry, physics and engineering. There is increasing desire for more graduates in all STEM-related subjects and greater engagement with universities to support iwi development and meet future needs.

Current government priorities in education

In their 'Statement of Intent 2009-2014' the Government identified six priority outcomes for 2009/2012 on which the Ministry of Education will focus its resources and funding:

- Every child has the opportunity to participate in high quality early childhood education
- Every child achieves literacy and numeracy levels that enable their success
- Every young person has the skills and qualifications to contribute to their and New Zealand's future
- Relevant and efficient tertiary education provision that meets student and labour market needs
- Māori enjoying education success as Māori
- The Ministry is capable, efficient and responsive to achieve education priorities.

While improved Māori student achievement has been a key Government priority in education over the last decade, Government agencies recognise there are significant challenges facing them and educational institutions if we are to realise Māori potential (Education Review Office, 2010a). In *Ngā Haeata Mātauranga 2008/09*, the Ministry of Education's Annual Report on Māori Education, The Hon. Dr Pita Sharples writes, 'The challenge is to create an education system that supports the right of Māori students to live and learn as Māori, to reach their potential, and go on to contribute to their whānau, iwi and our nation' (Ministry of Education, 2010, p. 4). There are two explicit goals in this statement. The first is to create an environment that allows Māori students to succeed as Māori. This is seen as an inherent right of all Māori students, to be able to access and have the opportunity to engage with and learn about te ao Māori (the Māori world) in order to prepare them to live in Māori society. The second goal is for Māori students to succeed on the same terms as their Pākehā peers, to have access to global knowledge and achieve in the environment of the knowledge economy. The real challenge for the education system is to deliver equally on both these goals.

There is therefore a focus in contemporary education policy on education to equip students to contribute to their own and New Zealand's future, and the educational success of Māori. '*Ka Hikitia - Managing for Success: The Māori Education Strategy 2008 – 2012'* sets out the Ministry of Education's strategic approach to achieving educational success for and with Māori through to 2012. It is currently being re-developed in the form of '*Ka Hikitia – Accelerating Success 2013–2017'*, which will focus on attaining a greater step-up in achievement for and with Māori learners.

The large proportion of Pasifika, and their relative under-achievement compared with their European counterparts, has also resulted in Government policy focusing on enhancing their educational engagement achievement. For example, the vision of the '*Pasifika Education Plan 2009-2012'* is that 'the education system must work for Pasifika so they gain the knowledge and skills necessary to do well for themselves, their communities, Aotearoa New Zealand, the Pacific region and the world'.

New Zealand's education sector

Early childhood education (ECE)

The 1980s and 1990s saw a renewed interest in the potential of good-quality early childhood education. Early childhood education has existed in NZ since the late nineteenth century, where it was concerned with the care of poor children and improving the homes children came from (May, 1997). At the same time as the renewed interest in ECE, the Māori medium education movement established Ngā Kōhanga Reo (literally 'language nests') in 1982 in response to language loss and as a critique to colonialism, among other reasons.

In the 1990s the Government established a working party to develop a curriculum that would/could be used for all early years children. The resulting curriculum, Te Whāriki[6] (Ministry of Education, 1996), published in English and Māori, is revolutionary in that it is a national curriculum outside the compulsory education sectors, focuses on the development of learner dispositions, and is strongly bicultural/bilingual. Furthermore, a new assessment approach of 'learning stories' was developed to support the sociocultural focus of the curriculum, which ulitise a narrative format contributed to by the teacher, the child and parents/whānau (extended family)/caregiver to represent children's learning (Carr, 1991).

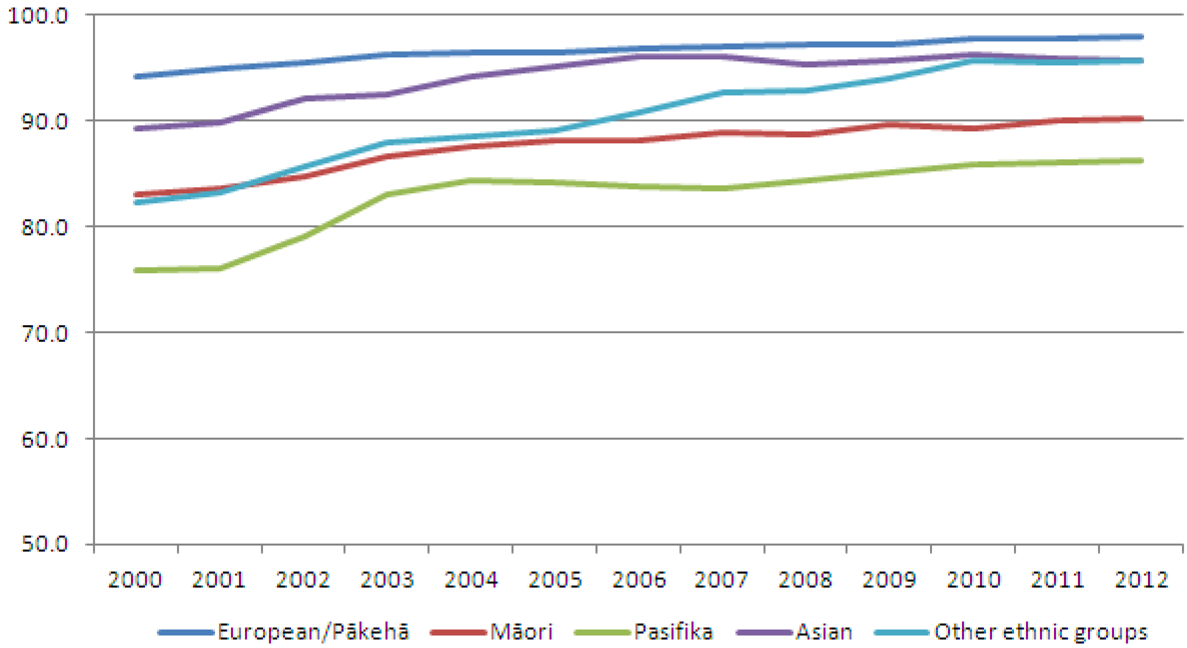
New Zealand has a '20 Hours ECE' programme which enables all three, four and five year old children, whether NZ residents/citizens or not, to access early childhood education for up to 6 hours per day, up to 20 hours per week. ECE services cannot charge any fees for hours claimed as ECE. From February 2011, teacher-led ECE services[7] with more than 80% qualified teachers were able to ask parents for 'optional charges' within their 20 Hours ECE entitlement.

As shown in Figure 1, there have been steady rises in ECE participation between 2000 and 2012. European children were the most likely to attend ECE across this period, while Māori and Pasifika children continued to be the least likely to attend. However, the rise in participation was greatest for the Pasifika and Māori ethnic groups and by 2012, 87% of Pasifika and 91% percent of Māori children had participated in ECE before starting school, compared with 76% and 83%, respectively, in 2000.

[6] The Māori word for a type of woven mat.

[7] Teacher-led centres have one or more ECE-qualified and registered teachers responsible for the overall programme and differ from parent-led centres such as Playcentre, kōhanga reo and playgroups. These parent-led centres are responsible for implementing Te Whāriki.

Figure 1: Prior participation in ECE of children starting school, 2000-2012[8]



Despite these large proportions of students attending ECE prior to enrolling in school, only 3% of 2011 TIMMS Year 5 students attended schools where the principal thought 75% of students entered the primary grades with early numeracy skills (Mullis et al., 2012, p. 222) and 8% were at schools with 51-75% of the students entering with early numeracy skills. In other words, nearly 90% of the TIMSS cohort were at schools where principals considered less than 50% of their students entered school with early numeracy skills.

The compulsory school sector

New Zealand's compulsory education sector includes public/state (Government-funded), state-integrated (Government-funded with special character, usually church schools) and private schools, mostly taught in English language. A small proportion of the state and state-integrated schools offer bilingual and/or Māori immersion education. In support of 'Māori succeeding as Māori' an alternative Māori-medium schooling system was established in the 1980s that consists of Kohanga Reo (early childhood), kura kaupapa (primary education), and wharekura (secondary education) and sits alongside the English-medium education system. The kura kaupapa Māori (KKM) system teaches in te reo Māori (Māori language) and the curriculum is based on Māori values, philosophies, principles and practices. Upon the establishment of this alternate system there now exists other alternates, such as bilingual classes/schools and Māori enrichment classes in English medium schools, and Māori /English bilingual schools.

Education in New Zealand is compulsory for all children aged between six and 16 years although in practise most children enrol at school on their fifth birthday. Primary schools are the first level of compulsory schooling. They cater for children from the age of five years to the end of their 8th year of schooling. Children in Years 7 and 8 may either be in a separate intermediate school or part of a full primary (Years 1-8), middle (Years 7-9 or 10), secondary (Years 7–13) or composite/area school (Years 1-12 or 13). Most secondary schools provide for students from Year 9 until the end of Year 13.

[8] http://www.educationcounts.govt.nz

The most significant challenge for Māori educational advancement is what happens for the majority of Māori students who are in predominantly English-medium schools. Viability of this schooling form is crucial. English-medium schools are where Māori dimensions are added onto an existing framework, what Durie (2001, p. 8) calls 'the Māori added pathway'. While adding Māori components to existing curriculum alone has not shown promise for shifting achievement patterns, attitudes towards Māori agendas and programmes have shifted considerably within this framework over the last 40 years. However, in the context of self-managing schools (see below) such developments have occurred in ad hoc ways.

The Ministry of Education has made Māori success and achievement a priority, among other goals, for the next 5 years. For the KKM system the challenge is not about whether the students experience and identify with their 'Māoriness' (all students emerge proficient in te reo Māori and with extensive Māori knowledge), but is related to curriculum. KKM tend to be small schools and cannot offer the range of curricula found in mainstream schools. STEM subjects are most affected in this system as there are few Māori speaking, STEM-qualified teachers. For mainstream schools the challenges are different and extensive. Māori students have a long history of failing in English medium schools and issues include attitudes and expectations of teachers and students, teacher quality in predominantly Māori schools, and parental engagement. These can also not be considered in isolation from wider contextual factors such as poverty and greater risk of poor health. The focus of current research and policy indicates that school-level developments for Māori student success include: school leadership, teacher quality, effective engagement with family/whānau, opportunity and access to curriculum, and student retention.

School governance

All state and state-integrated schools are governed independently by a Board of Trustees, who have the responsibility for employing the school's staff and:

- setting the school's strategic and policy direction in consultation with parents, staff and students
- ensuring that the school provides a safe environment and quality education for all its students
- overseeing the management of curriculum, staff, property, finance and administration
- monitoring and reviewing progress against annual goals and targets to inform future planning.[9]

This self-management of schools came into being with the 'Tomorrow's Schools' reforms legislated in the Education Act (1989). While this move was to encourage greater parental involvement, it was not clear in the framing documents whether, and how, parents and communities might be involved in curriculum decision-making. The success of the model is also dependent on school leadership and the quality and range of skills a school has in its community. The model therefore has had mixed success with a tendency to be poor or fail in rural, low SES communities. When the model fails the Ministry of Education appoints a limited statutory manager or, alternately, dismisses the Board of Trustees and appoints a Commissioner.

[9] http://www.minedu.govt.nz/Parents/AllAges/EducationInNZ/SchoolsInNewZealand/BoardsOfTrustees.aspx

The school curriculum

New Zealand has a long history of national curriculum and schooling policy, with New Zealand teachers implementing national curricula in various guises since 1877. In its early versions, the curriculum differentiated between the sexes, and between Māori (vocational) and non-Māori (academic). It was slow to respond to economic changes of the 1970s and its relevancy was questioned. By the 1980s, the direction and purpose of the school curriculum was a topic for public debate and a target by lobbyists for change. For instance, public discussion and consultation was considerable, with 31,500 submissions (out of a population of 3 million) received in response to a curriculum review launched in 1984.

In 1991, the Ministerial Task Group Reviewing Science and Technology Education was set up jointly by the Minister of Education and the Minister of Research, Science and Technology and charged with assessing 'the effectiveness of science and technology education in delivering the skills and knowledge required by society and the workplace' (Ministry of Research, Science and Technology, 1992, p. 8). This reflected the criticism levelled at previous curriculum developments (Cowie & Jones, 2010). Some of the recommendations relevant to the curriculum were:

- the need for the national curriculum to teach and assess interpersonal, communication and broadly-based practical skills;
- the curriculum should define a broad range of knowledge and skills which should be recognised by assessment procedures; and
- a general science curriculum suitable for all students up to Form 7 [Year 13] should be developed, and that specialist science courses should be restricted to Form 6 [Year 12] and beyond (Ministry of Research, Science and Technology, 1992).

The recommendations also gave support for consideration of gender issues in science education, the need for vocabulary development in Māori relating to science education, and teaching of science in Māori.

The New Zealand Curriculum Framework (Ministry of Education, 1993) specified seven essential learning areas that describe in broad terms the knowledge and understandings which all students need to acquire. They were: health and well-being, the arts, social sciences, technology, science, mathematics, and language and languages. The curricula were produced in English and Māori languages. In relation to the latter, it was the first time New Zealand had written a curriculum document in te reo Māori (previous Māori language subject documents only had the Māori vocabulary to be learned written in Māori).

Schools were required to ensure all students undertook continued study in each of the learning areas in the first ten years of schooling but they had flexibility in how this would be achieved and were responsible for making implementation decisions. The New Zealand Curriculum Framework also required the development of essential skills across each of the learning areas. These were communication, numeracy, information, problem-solving, self-management and competitive, social and co-operative, physical, and work and study skills. In addition, the Framework recognised the Treaty of Waitangi and stated that recognition will be given to the 'unique position of Māori in New Zealand society' (p. 7), that Māori children will have access to Māori language, and the curriculum, generally, will include Māori history and values.

The Curriculum Framework was revised and re-launched in 2004, again in both English and Māori. Some of the major changes in the revised New Zealand Curriculum (Ministry of Education, 2007) included:

- a shift from “essential skills” to “key competencies” that integrate knowledge, skills, attitudes and values;
- expanded statements on values in the curriculum;
- inclusion of five future-focused themes: sustainability; citizenship; enterprise; globalization and critical literacies;
- guidelines on school-based curriculum design;
- a clearer vision statement;
- advice on pedagogy and on assessment;
- a reduction in the achievement objectives in all learning areas and the inclusion of these in one streamlined document rather than 7 separate documents; and
- an increased emphasis on the teaching of languages other than English.

Of particular interest in NZ curriculum development is the language development that needed to take place for the Māori language versions of science (pūtaiao), mathematics (pāngarau) and, to a lesser extent, technology (hangarau). McKinley and Keegan (2008), in one of the few papers written on this topic, asked what happens in translation work in relation to development of a new technical language based on the language of instruction. They argued that the development of new terminology, no matter how culturally sensitive the process is, creates new problems. First, the new words can be perceived as representing traditional knowledge and, secondly, traditional Māori knowledge will be erased with the new language. The challenge presented to all concerned is how students will develop a more authentic experience of Māori language, knowledge and culture. The paper concludes that the journey between science and pūtaiao is an ongoing transformation based on language and the epistemology held within and is made more complex by the relationships that exist between L1 (home), L2 (school), and L3 (discipline specific) in a language revitalisation context.

Within KKM, the challenge in terms of raising Māori engagement and achievement is not about whether the students experience and identify with their ‘Māoriness’ (all students emerge proficient in te reo Māori and with extensive Māori knowledge), but is related to curriculum. KKM tend to be small schools and cannot offer the range of curricula found in mainstream schools. STEM subjects are most affected in this system as there are few Māori speaking, STEM-qualified teachers. For mainstream schools the challenges are different and extensive. Māori students have a long history of failing in English medium schools and issues include attitudes and expectations of teachers and students, teacher quality in predominantly Māori schools, and parental engagement. These can also not be considered in isolation from wider contextual factors such as poverty and greater risk of poor health.

New Zealand’s assessment framework

The National Certificate in Educational Achievement (NCEA) is a standards-based qualification that was introduced in 2002 as the main secondary school qualification for Years 11, 12 and 13. It replaced an examination-based qualification system.

The NCEA system is supposed to provide a more accurate picture of a student’s achievement because a student who has gained credits for a particular standard has demonstrated the required skills and knowledge for that standard.[10] Furthermore, a student’s Record of Learning (RoL) documents each standard the student has entered and the credits and endorsements awarded. It therefore documents much more than a subject name and a grade or percentage.

When a student achieves a standard in NCEA, they gain a number of credits. A certain number of credits is needed to gain an NCEA certificate, which is awarded at Levels 1, 2 and 3 that students generally work through in Years 11 to 13. Work for each standard is

---

[10] http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/understanding-ncea/history-of-ncea/

judged as being not achieved (N), achieved (A), achieved with merit (M), or achieved with excellence (E). Since 2007 certificate endorsements were introduced to recognise student achievement at merit or excellence level across more than one learning area. In other words, NCEA Level 1, 2 and 3 can be achieved with merit or excellence.

From 2010, the ‘Alignment of Standards with the New Zealand Curriculum’ project began reviewing all standards to align them with the NZ Curriculum and address duplication issues. The revised Level 1 standards were implemented in 2011, Level 2 in 2012 and Level 3 are due to be implemented in 2013.

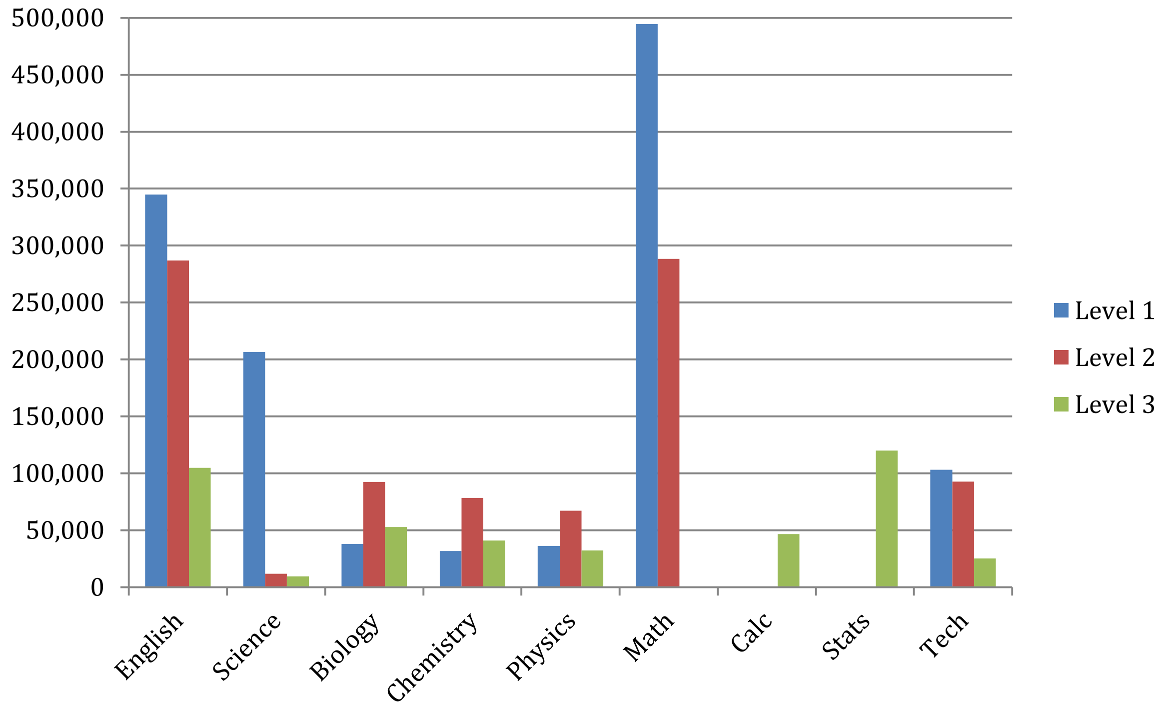
In relation to STEM subjects, data for 2011 (see Figure 2) shows that while a large proportion of students take mathematics at Level 1 and Level 2, fewer students enrol in science (and related individual sciences) at Level 1 (when it is still a compulsory subject in many but not all schools), and this drops off at Levels 2 and 3. Even fewer students do technology.

Special case: science standards

Science has an extensive range of standards that can be used to design and assess senior courses in comparison to what is available in other subjects. This can, and does, allow for greater flexibility in course design. This arrangement allows schools to deliver programmes that not only engage students, but that also reflect the multi- and inter-disciplinary nature of modern science, such as biotechnology or forensic science. In addition, the variety of standards allows for greater customisation of individual learning programmes and qualifications that can be tailored to meet the diverse needs of students. A further flexibility occurs with transitions between vocation and academic pathways, and secondary and tertiary qualifications, as all standards are part of the same qualifications framework.

Balanced against the potential for flexibility to allow expanded notions of what it means to do science (and to a lesser extent other STEM subjects) in school is that a school – or individual teacher – can design a legitimate science programme where key themes may not be taught because they are not being assessed. There is an argument that perhaps this does not matter – particularly if the courses foster student engagement. However, this argument assumes two things – first, that students are passive bystanders in the whole scenario, and second, all interfaces with secondary education can and will adjust to decisions taken by schools/teachers.

Figure 2: Number of unit and achievement standard entries in 2011[11, 12]



Students can, and do, 'work' the system. Meyer et al. (2006), investigating the impact of NCEA on student motivation, found that students deliberately skipped parts of a course that they did not like, thought they would do poorly at, or thought were too challenging. Students in this study also reported not wanting to participate in external examinations once they had achieved the required number of credits to be awarded the qualification. While the recent inclusion of qualification endorsements is intended to ameliorate the issue of motivation to some extent, it is too early to make a judgment on it yet. Further investigation is being undertaken in some schools as to what might encourage and assist students in taking examinations.

Unfortunately, many schools and teachers have also been shown to have a poor understanding of the detail of the NCEA qualification, and the meeting of university entrance criteria (Madjar et al., 2009). While teachers have a firm grasp on the understanding of the assessment in their teaching subject areas, far too many did not know how a student's programme led to an NCEA qualification nor whether a student's programme would lead to their career plans (McKinley et al., 2009). This lack of intimate knowledge of the qualifications system has a particularly adverse affect on Māori and Pasifika students and other students from low SES communities, where communities strive for their children to have the best but have little knowledge of how to realise these aspirations. The lack of qualification/career knowledge among staff generally, and the assumption and acceptance that it is a student's responsibility to watch out for themselves and self-initiate engagement with careers information, suggests there are plenty of cracks for our more vulnerable student populations to fall between.

Another aspect – which of course plagues all assessment regimes – is the strong influence of high stakes testing on classroom practice and the curriculum experienced by students. Hume and Coll (2010) found, for example, that extensive use of planning templates and exemplar assessment schedules to evaluate the Level 1 standard 'Carry out a practical investigation with direction' meant that 'what students came to perceive and experience as scientific investigation was the single, linear and unproblematic

---

11 Unit standards were phased out during the alignment process.

12 http://www.nzqa.govt.nz/qualifications/ssq/statistics/provider-selected-crystalreport.do

methodology of fair testing' (p. 56), with little opportunity to come up with original questions and solutions to experimental design – or even to integrate this with other parts of their science course(s). Moeed (2010) similarly found that the NCEA templates were used to present students repeatedly with one type of investigation, thus promoting a very narrow view of science investigation. However, she points out the tension teachers experience between balancing their reservations about the assessment, and their responsibility to help students achieve academic success. In many schools, she suggests, teaching, learning and motivation to learn 'science investigation' are being overwhelmed by the assessment regime.

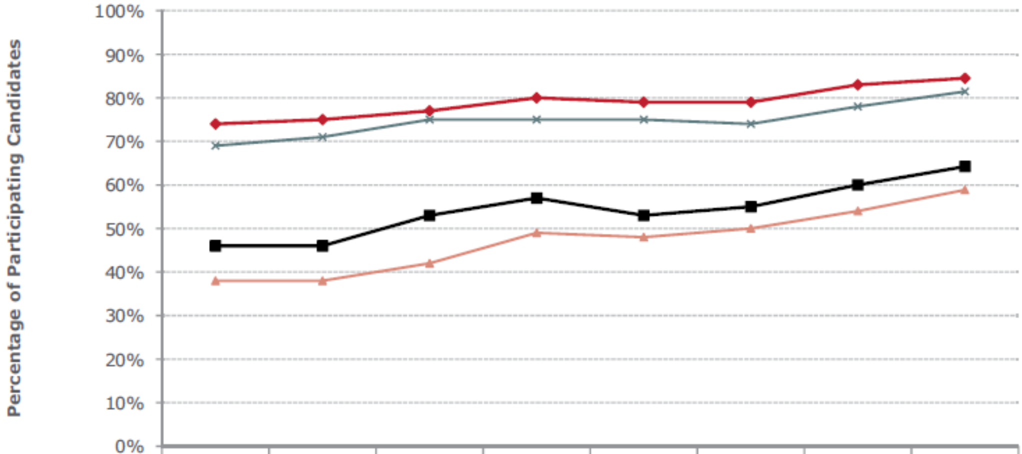
University entrance requirements also impinge on the types of science courses schools choose to offer. Herein lies a dichotomy, with university science increasingly reflecting the multi- and inter-disciplinary nature of modern science endeavours, but university administration continuing to require a large number of credits in discrete, traditional bundles like chemistry and biology in a conservative effort to 'maintain standards'. The value of this is further questioned by the finding that higher performance at university is more closely related to how well students performed at school, rather than to the particular subjects they studied (Engler, 2010).

In theory, therefore, the opportunities for flexibility provided by the large number of science assessment standards broadens the scope for developing engaging, context-based science courses. However, insufficient targeted professional development and the ongoing pressures from university entrance requirements have in practice constrained what many schools offer their students in terms of science.

NCEA achievement

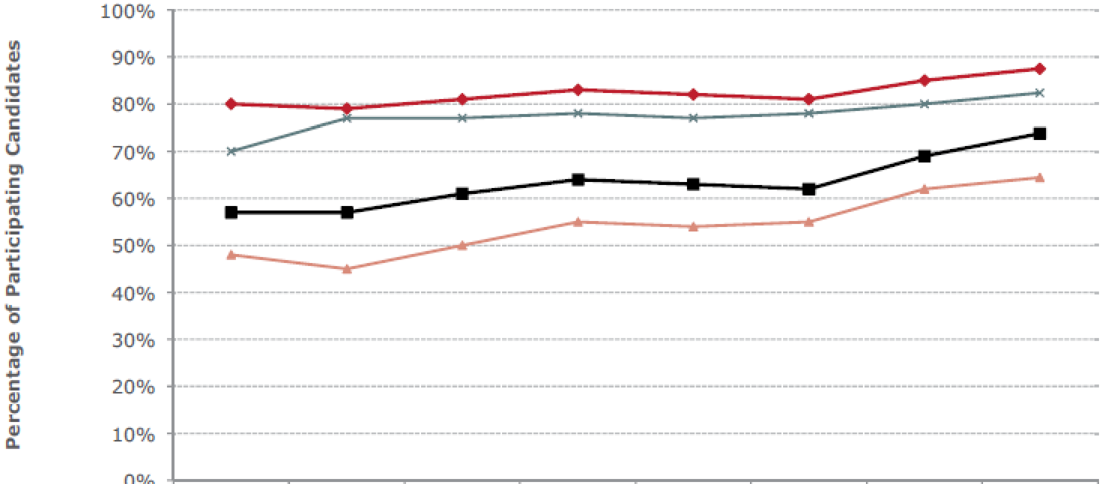
As can be seen in Figure 3, there has been a general increase in the attainment of Level 1 NCEA by all ethnicities since 2004, although the success rates of Māori and Pasifika students continues to lag behind their Pākehā and Asians counterparts. This trend is repeated for NCEA attainment at Levels 2 and 3 (Figures 4 and 5). Māori and Pasifika attainment also sat at around 50% compared with 70% for Pākehā in 2004. A comparison of success rates from 2004 to 2011 for each Level indicates that there is an increase of about 7 to 10 percentage points for Pākehā students while that of Māori students increase by 15 to 18 percentage points and Pasifika students by 14 to 21 percentage points. The success rate for Asian students increases by 11 to 12 percentage points. The gap between NCEA Level 2 and 3 attainment rates for New Zealand Māori and Pasifika candidates, and those for New Zealand European and Asian candidates, was less in 2011 than in any prior year.

Figure 3: Participating Year 11 candidates attaining NCEA Level 1, by ethnicity[13]



	2004	2005	2006	2007	2008	2009	2010	2011
NZ European	74%	75%	77%	80%	79%	79%	83%	84%
NZ Māori	46%	46%	53%	57%	53%	55%	60%	64%
Pasifika	38%	38%	42%	49%	48%	50%	54%	59%
Asian	69%	71%	75%	75%	75%	74%	78%	81%

Figure 4: Participating Year 12 candidates attaining NCEA Level 2, by ethnicity[14]

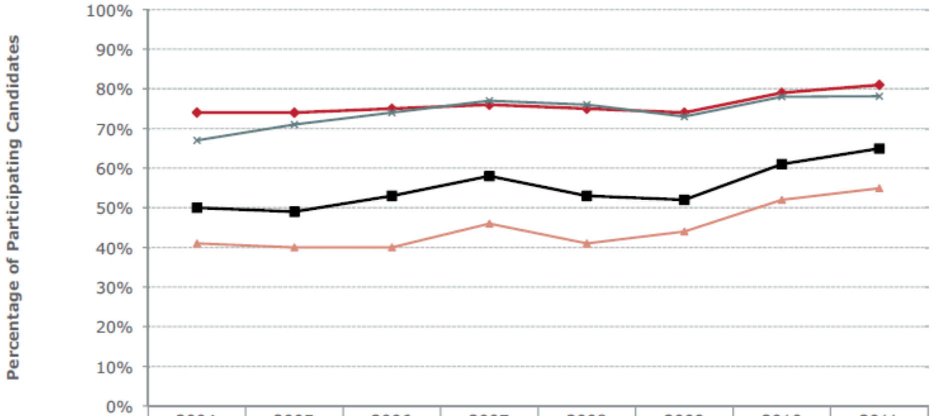


	2004	2005	2006	2007	2008	2009	2010	2011
NZ European	80%	79%	81%	83%	82%	81%	85%	87%
NZ Māori	57%	57%	61%	64%	63%	62%	69%	74%
Pasifika	48%	45%	50%	55%	54%	55%	62%	64%
Asian	70%	77%	77%	78%	77%	78%	80%	82%

[13] NZQA Annual Report on NCEA and New Zealand Scholarship data and statistics 2011

[14] NZQA Annual Report on NCEA and New Zealand Scholarship data and statistics 2011

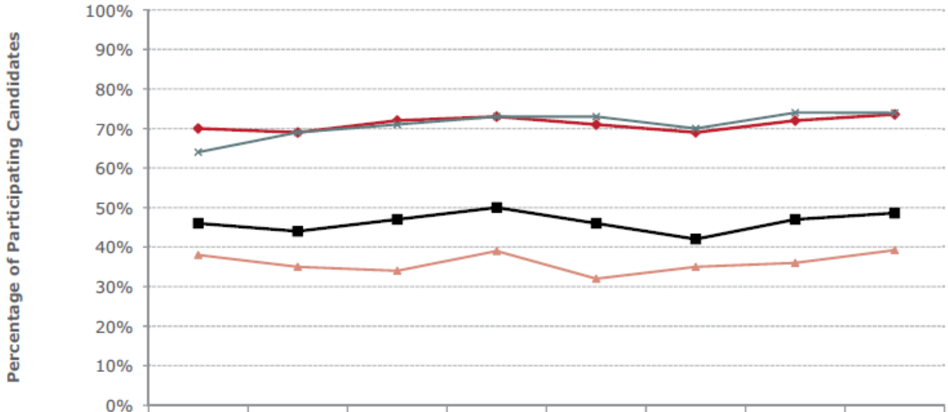
Figure 5: Participating Year 13 candidates attaining NCEA Level 3, by ethnicity[15]



	2004	2005	2006	2007	2008	2009	2010	2011
NZ European	74%	74%	75%	76%	75%	74%	79%	81%
NZ Māori	50%	49%	53%	58%	53%	52%	61%	65%
Pasifika	41%	40%	40%	46%	41%	44%	52%	55%
Asian	67%	71%	74%	77%	76%	73%	78%	78%

Figure 6 shows the percentage of students achieving the minimum requirement to be admitted for enrolment in a NZ university. Although attainment of University Entrance (UE) has fluctuated more among Māori and Pasifika candidates than Asian and Pākehā candidates, they are currently at their highest rate.

Figure 6: Participating Year 13 candidates attaining University Entrance, by ethnicity[16]



	2004	2005	2006	2007	2008	2009	2010	2011
NZ European	70%	69%	72%	73%	71%	69%	72%	74%
NZ Māori	46%	44%	47%	50%	46%	42%	47%	49%
Pasifika	38%	35%	34%	39%	32%	35%	36%	39%
Asian	64%	69%	71%	73%	73%	70%	74%	74%

Despite the increase in the number of Māori students attaining UE and the narrowing of the gap between NZ European and Māori students in NCEA success rates, longitudinal analysis of the 2009 cohort of students taking NCEA shows that a lower proportion of Māori students achieved NCEA qualifications than other ethnic groups (Figure 7). In other words, a large proportion of Māori students leave school with fewer qualifications than other students.

[15] NZQA Annual Report on NCEA and New Zealand Scholarship data and statistics 2011

[16] NZQA Annual Report on NCEA and New Zealand Scholarship data and statistics 2011

Figure 7: Tracking achievements of students who enrolled for NCEA Level 1 in 2009, as at end of 2011[17]

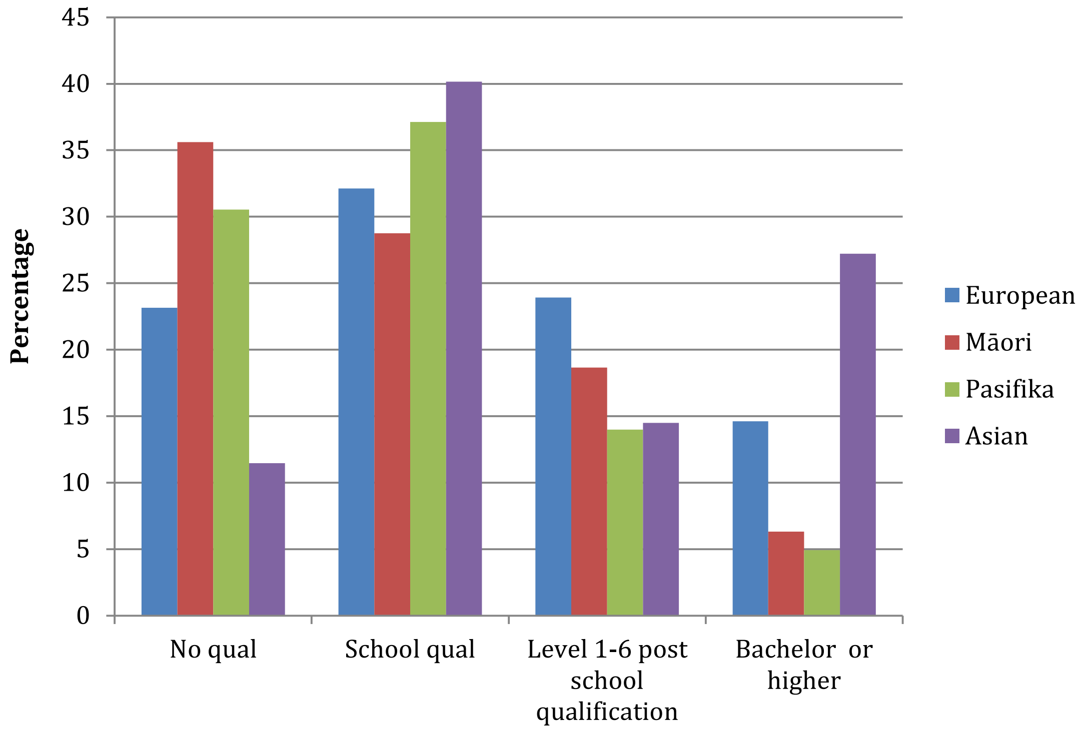
Ethnicity	Attained Level 1 by end of Year 13	Attained Level 2 by end of Year 13	Attained Level 3 by end of Year 13	No. of candidates in cohort
NZ European	86.0%	74.1%	47.0%	34,292
NZ Māori	68.3%	52.6%	22.7%	12,249
Pasifika	75.3%	63.9%	26.7%	5,678
Asian	84.5%	78.1%	54.3%	6,292

Qualifications and employment in New Zealand

Tertiary education is provided through eight universities, 18 Institutes of Technologies and polytechnics (ITPs), a large number of Industry Training Organisations (ITOs) and Private Training Enterprises (PTEs), and three Wānanga ('Māori universities' which are guided by Māori principles and values). The universities, ITPs, and wānanga are all state-owned.

Figure 8, drawing on 2006 census data[18] shows that NZ European/Pākehā and Asian populations are more likely to have a formal educational qualification than Māori and Pasifika. More recent Asian immigrants have the highest level of qualifications.

Figure 8: Rate of qualification achievement by ethnic group[19]
(Data are for 2006; n=2,072,862 Pākehā; 356,406 Māori; 165,630 Pasifika; and 277,599 Asian; percentages do not total 100 because of the number of census respondents who did not give their qualification status)

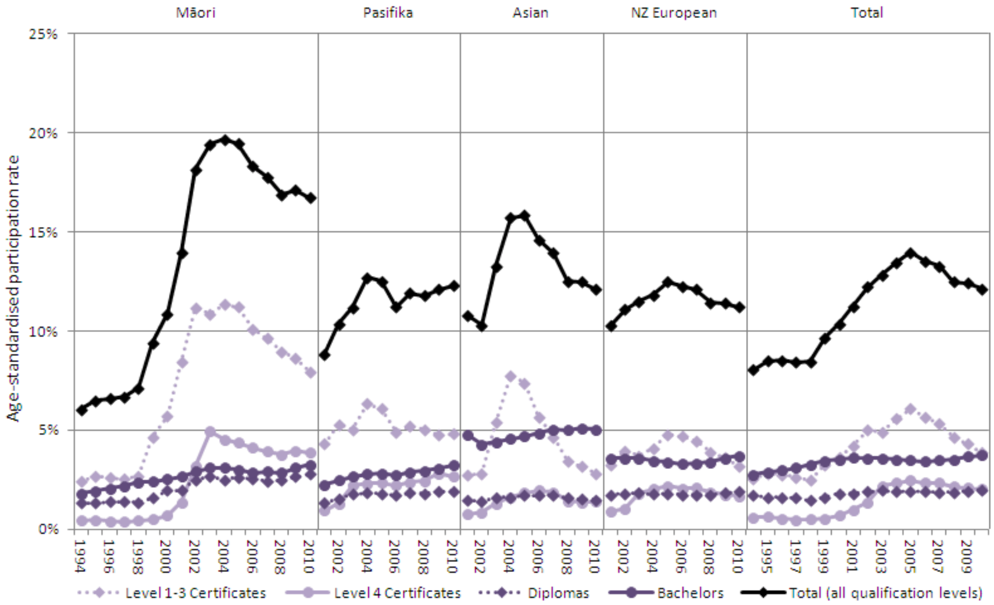


As shown in Figure 9, total participation rates in tertiary education declined from 2005 to 2010. However, the Māori participation rate in tertiary education has more than doubled since 1998, such that Māori now participate in tertiary education at a higher rate than non-Māori: After adjusting for differences in age distributions, 16.7% of Māori aged 15

17 NZQA Annual Report on NCEA and New Zealand Scholarship data and statistics 2011
18 The planned 2011 census was cancelled as a result of the Christchurch earthquake and is now scheduled for 2013
19 http://www.stats.govt.nz/browse_for_stats/income-and-work/employment_and_unemployment.aspx

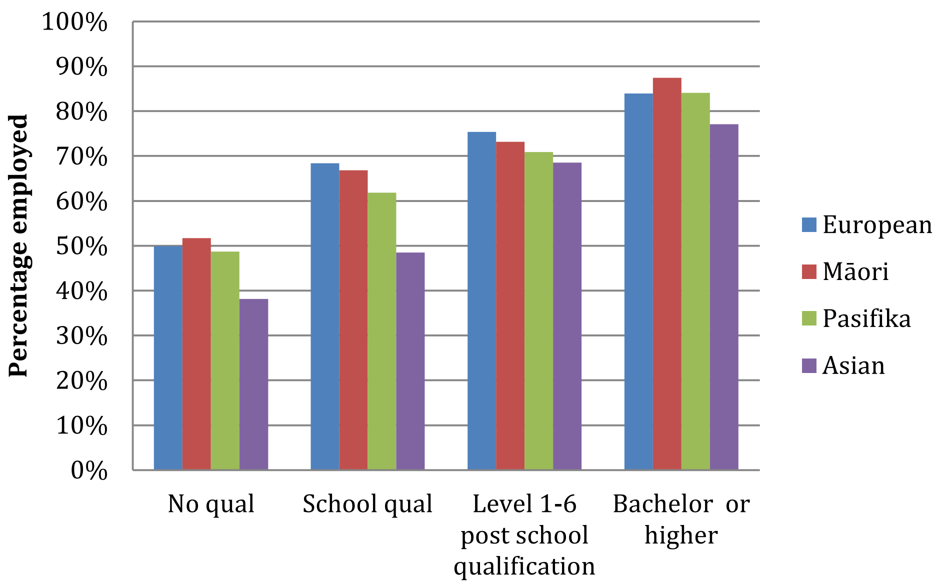
and over participated in tertiary education in 2010 compared with 11.2% of European/Pākehā, 12.3% of Pasifika and 12.1% of Asians.

Figure 9: Age-standardised participation rates in tertiary education for populations aged 15 plus, by ethnic group and level of study[20]



Not surprisingly, qualifications are linked with employment. Patterns of employment based on 2006 census data indicate that rates of employment increase with increasing levels of qualifications. Employment of Māori and Pasifika peoples is generally lower than for NZ European/Pākehā except at the degree level or higher (see Figure 10), at which point, a higher percentage of Māori with a degree are likely to be employed than their NZ European/Pākehā counterparts.

Figure 10: Rate of employment by level of qualification for each ethnic group[21]
(Data are for 2006; n=2,072,862 NZ European/Pākehā; 356,406 Māori; 165,630 Pasifika; and 277,599 Asian)



---

[20] http://www.educationcounts.govt.nz/indicators/main/student-engagement-participation/1963
[21] http://www.stats.govt.nz/browse_for_stats/income-and-work/employment_and_unemployment.aspx

Summary

The section above is intended to contextualise STEM education within the context of Aotearoa New Zealand. The following are key points:

1. Aotearoa New Zealand is a multicultural nation. Māori, as the indigenous people, have specific statutory rights under the Treaty of Waitangi, the nation's founding document. Immigrants from the Pacific Islands and Asia also represent significant ethnic groups.
2. Māori and NZ European/Pākehā populations are significantly integrated. There is no history of legislated segregated areas for indigenous people.
3. Māori iwi hold significant economic wealth.
4. In the 1970s, grave concerns were expressed by Māori educators about the survival of the Māori language – all formal education was offered in English. In 1987 New Zealand became officially bilingual.
5. While the majority of state-funded schools are English medium, some are bilingual and Kura kaupapa Māori (KKM) are full immersion Māori schools. In nearly all measures of educational section, Māori and Pacific Island peoples (Pasifika) as ethnic groups tend to do less well than their European or Asian counterparts.
6. Te Taura Whirl i te Reo Māori (The Māori Language Commission) has the task of developing all aspects of the language, including scientific vocabulary.
7. The Government currently prioritises the educational success of Māori as Māori. It is seen as an inherent right of all Māori students that they have the opportunity to engage with and learn about te ao Māori (the Māori world), and to succeed on the same terms as their Pākehā peers. The real challenge for the education system is to deliver equally on both these goals.
8. The large proportion of Pasifika, and their relative under-achievement compared with their European counterparts, has also resulted in Government policy focusing on enhancing their educational engagement achievement.
9. The early childhood and school curricula are published in both English and Māori. Science (pūtaiao), technology (hangarau) and mathematics (pāngarau) are represented as distinct learning areas. The translation and language development work is complex and, no matter how culturally sensitive the process is, problems arise.
10. In relation to the Ministry of Education's goals to enhance Māori engagement and achievement, the challenge within the KKM system is not whether the students experience and identify with their 'Māoriness', but is related to offering high quality curriculum choices. KKM tend to be small schools and cannot offer the range of curricula found in mainstream schools. STEM subjects are most affected in this system as there are few Māori speaking, STEM-qualified teachers.
11. For mainstream schools, raising Māori engagement and achievement requires a range of complex, interacting issues to be addressed, including attitudes and expectations of teachers and students, teacher quality in predominantly Māori schools, and parental engagement. These can also not be considered in isolation from wider contextual factors such as poverty and greater risk of poor health.
12. New Zealand's assessment framework at senior secondary school (NCEA) is standards-based and schools have enormous flexibility in design education programmes. In general, the opportunity for designing innovative and engaging STEM-related programmes has not yet been realised.
13. Despite the increase in the number of Māori students attaining University Entrance (UE) and the narrowing of the gap between NZ European and Māori students in NCEA success rates, longitudinal analysis of the 2009 cohort of students taking NCEA shows that a lower proportion of Māori students achieved NCEA qualifications than other ethnic groups (Figure 7). In other words, a large proportion of Māori students leave school with fewer qualifications than other students.
14. When considering secondary and tertiary qualifications, Pākehā and Asian populations are more likely to have formal educational qualification than Māori and

Pasifika, although the proportion of Māori entering tertiary education has doubled since 1998.

15. Employment of Māori and Pasifika peoples is generally lower than for Pākehā except at the degree level or higher, at which point a higher percentage of Māori with a degree are likely to be employed than their Pākehā counterparts.

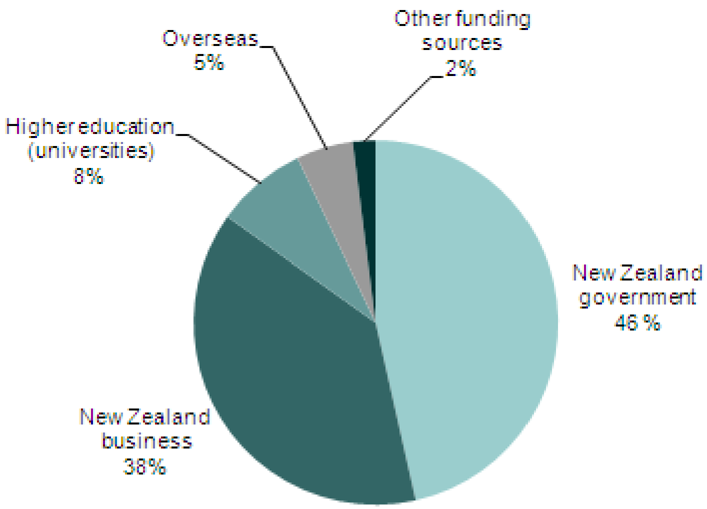
Attitudes to STEM

Government policy related to funding STEM-related research

The New Zealand Government, like many governments around the world, appears to be placing increasing emphasis on the role of STEM-related research and development for economic and social development. For instance, the pursuit of STEM to drive economic growth has seen a shift in the alignment of Government agencies from single, small policy agencies such as the Ministry of Research, Science and Technology, to the creation of the Ministry of Science and Innovation (bringing together both policy and funding functions) in February 2011. This was changed again in June 2012 to create the Ministry of Business, Innovation and Employment, which brings together science and innovation, economic development, labour, immigration, consumer affairs, and building and housing. The mandate of this super-Ministry is to 'be a catalyst for a high-performing economy to ensure New Zealand's lasting prosperity and wellbeing'.[22]

NZ's expenditure on R&D as a proportion of GDP increased from 1.15% in 2002 to 1.3% in 2010, or a total of NZ$ 2.4 billion. Nearly half of this (46%) was contributed by Government (see Figure 11). The Government, like many around the world, is focusing on aligning its science funding more with business and future national needs.

Figure 11: Research and development expenditure for 2010 by source of funds.[23]



Tertiary institutions compete with Crown Research Institutes and private research organisations for Government research funding. This includes the Marsden Fund (NZ$ 54.6 million), which funds blue-skies research predominantly in STEM areas (eight of the eleven panels are directly related to STEM).

Within tertiary education institutions, the Performance-Based Research Fund (PBRF) – analogous to the Excellence in Research for Australia (ERA) in Australia and the Research Assessment Exercise (RAE) in the UK – allocates funding based on research outputs, peer esteem, and contribution to the research environment. It was taken out of

22 http://www.mbie.govt.nz/
23 http://www.mbie.govt.nz/

the student fund, so there was no increase in dollar value, although it did mean a slight re-distribution of funds within the sector. The ratio of funding that is allocated is based on the same cost categories used for SAC (student achievement component) funding, with Science PBRF scores being awarded 1.75 times the amount of funding than Arts, and Engineering double the funding of Arts. This is likely associated with the greater costs of education and research in science and engineering when compared with the arts.

Societal attitudes to STEM

In order to understand public attitudes toward science and technology, the Ministry of Research, Science and Technology undertook a benchmark study in 2002. The study was repeated in 2005 and 2010 (AC Nielsen, 2010). The research assessed: perceived benefits of development in areas of science and technology; the relationship between science and economic success; and sociological aspects of science. Structured telephone interviews were used in all years and an online version of the survey was also used in 2010. The sample size in 2010 was 1,200.

'New medical techniques and treatments', 'improving the quality of our agriculture and horticulture' and 'new forms of energy for transport' were rated as being the most beneficial areas of scientific development, with development in 'communication technologies' gaining prominence in 2010 when compared with 2002 and 2005. There was also strong support for 'saving endangered species' (79% in 2010), 'understanding earthquakes and their effects on people' (75%)[24] and 'genetic testing for human health issues' (67%). Only 58% agreed or strongly agreed that there are benefits associated with research into climate change, and 40% (up from 28% in 2005) that there are benefits associated with space research and astronomy.

More than three quarters of the 2010 respondents (76%) agreed or strongly agreed that it is important to be kept up-to-date on science issues, and nearly three quarters (72%) agreed or strongly agreed that they enjoy finding out about new ideas in science. However, only just over half indicated that science is important in their daily lives (56%, down from 65% in 2005) and that there is so much conflicting information about science it is hard to know what to believe (53%, up from 49% in 2005). Interestingly, the youngest respondents (15-24 years) were significantly less likely than average to agree that it is important to be kept up-to-date on science issues (67% cf. 76%) and more likely to disagree that science is important in their daily lives (24% cf. 17%). Those with a higher household income (NZ$80,000 or over) were more likely to agree with the statements 'I enjoy finding out about new ideas in science' (78% cf. 73%) and 'science is important in my daily life' (61% cf. 56%). Those with a postgraduate university qualification were also more likely to agree with these statements (84% cf. 76%, and 80% cf. 56% respectively).

On the whole, science continued to be seen to be making an important contribution to New Zealand in terms of the preservation of our environment, and enhancing our international competitiveness. However, in 2010 there was significant lower agreement for the government to fund scientific research even if we can't be sure of the economic benefits (55% agreeing or strongly agreeing, cf. 67% in 2005). While this could be attributable to the current economic environment, Government policy suggests that investment in science and innovation are important to grow the economy. Again, the younger respondents (15-24 years) were less likely than average to agree that 'New Zealand needs to develop science in order to enhance our international competitiveness' (67% cf. 77%), and 'the government should fund scientific research even if we can't be sure of the economic benefits' (47% cf. 55%). Those with a household income over NZ$80,000, or who had a postgraduate qualification, were more likely to agree that 'New

[24] The survey was completed before the Christchurch earthquakes of 4 September 2010 and 22 February 2011.

Zealand needs to develop science in order to enhance our international competitiveness'.

Taken together, these findings indicate that there was general support for scientific research, particularly in areas that are viewed as important to the country's citizens – medical treatments and techniques, and agriculture and horticulture. Climate change was considered to be less important as an area of scientific research. Younger respondents without a postgraduate qualification or a science qualification were less likely than their older counterparts to be engaged in finding out about science.
As part of the Government's strategy to engage New Zealanders with science and technology, Ministry of Business, Innovation, and Employment funds the New Zealand Science Media Centre (www.sciencemediacentre.co.nz), which was launched in June 2008. It was conceptualised on the success of the Science Media Centres in both the UK and Australia. Science Media Centres have also since opened in Japan, Canada and Denmark.

School students' attitudes to STEM

School students' attitudes to science and mathematics are measured internationally by both TIMSS and PISA, although Buckley (2009) points out inherent problems with drawing accurate conclusions from these data given cross-national differences in response style. Of particular interest to New Zealand is the trend towards being high-achieving, but showing lower levels of interest in science when compared with the international mean. This is consistent, however, with the international trend for students in low-performing countries to show relatively high levels of interest in science, and students in high-achieving countries showing relatively lower levels of interest (Bybee & McCrae, 2011). However, within New Zealand – as within nearly all other countries – students with higher engagement in science (or mathematics) generally had higher achievement in science (or mathematics) than those with lower engagement.
In terms of attitudes to science, 55% of New Zealand's Year 5 students indicated that they liked learning science, with 13% not liking learning science. This was comparable with the international average (53% and 12% respectively) (Mullis et al., 2012, p. 323). However, this dropped by Year 9 to 24% who liked learning science, with 30% not liking it (compared with the international averages of 35% and 21% respectively). While this pattern is common internationally, with older students generally more discerning and critical, and also more realistic about their own abilities, it is also an international concern because of the longer term impacts on lifelong learning, scientific literacy, and informed citizenship (e.g., Gluckman, 2011).

As well as not liking science as much as their international counterparts, New Zealand's Year 9 students saw less value in learning science: 26% see it as having value and 41% as it not having value (cf. 41% and 26% internationally). Confidence in learning science was also low: 28% of New Zealand's Year 5s reported being confident, and 32% not confident (cf. 43% and 21% internationally); by Year 9 only 14% were confident in NZ and 40% not confident (cf. 20% and 31% internationally). Only 39% of Year 5 students were reported as being engaged in science lessons, compared with the international average of 45% (46% in Australia). By Year 9, engagement dropped to 21% (cf. 29% internationally and 21% in Australia).

The PISA data paints a similar picture, with 2006 attitudinal responses indicating that students were less interested in learning science topics than the OECD average (461 points *vs*. 500 points) although this is in keeping with the international trend for students in low-performing countries to show relatively high levels of interest in science (see below), and students in high-achieving countries showing relatively lower levels of interest (Bybee & McCrae, 2011).

Within New Zealand, the National Education Monitoring Project (NEMP) also collects attitudinal and achievement data. Consistent with the TIMSS findings, Year 4 students are generally more positive than Year 8s about doing science at school. While this pattern is common internationally, with older students generally more discerning and critical, and also more realistic about their own abilities, it is concerning that the percentage of Year 8 students enjoying science at school dropped from 37 to 24% from 1999 to 2007.

Attitudes to mathematics tend to be even less favourable than science: 47% of Year 5 students reported in TIMSS 2011 that they liked learning mathematics and 18% did not like it (cf. 55% and 13% for science). These attitudes to mathematics are very comparable with the international average, however (48% and 16% respectively) (Mullis et al., 2012). Māori and Pasifika students expressed lower self-confidence in mathematics compared with students in the Pākehā and Asian ethnic groupings (Ministry of Education, n.d.).

Attitudes decreased at Year 9, with only 17% of students reporting they liked learning mathematics and 42% who did not. These compare unfavourably with the international averages (26% and 31% respectively, but 16% and 45% in Australia). In terms of valuing mathematics, 46% of Year 9s value it and only 13% do not value it (cf. 46% and 15% internationally).

Confidence in learning mathematics is also low, with only 25% of Year 5s reporting in TIMSS 2011 that they feel confident (compared with 38% in Australia and 34% internationally), and 16% of Year 9 students (compared with 17% in Australia and 14% internationally). 36% of Year 5 students reported being engaged in mathematics lessons in 2011, with 8% not engaged (cf. 42% and 8% internationally). Engagement drops to 12% at Year 9, with 32% not engaged (cf. 25% and 21% internationally. Confidence and engagement are therefore lower than international averages at the primary level, and engagement but not confidence is lower at the secondary level.

New Zealand's Year 9 students' valuing of mathematics[25] was similar to the international average (56%, compared with 55% internationally). Asian and Pasifika students were more likely than their Māori and Pākehā counterparts to place high value on mathematics (76%, 72%, 57% and 50% respectively). Unlike in science, the value accorded to mathematics was related to achievement in New Zealand and most other countries. However, in New Zealand, this was more marked for Pākehā students than Māori students.[26, 27]

Choosing science and mathematics at school and beyond

Concern at declining enrolments in science at senior secondary and tertiary levels led the Ministry of Research, Science and Technology (MoRST) to commission the *Staying in Science* research (Hipkins & Bolstad, 2005; Hipkins et al., 2006) to investigate the study and potential career choices of students who chose to continue with science subjects in the senior secondary school. The results from these studies found New Zealand students chose science subjects for similar reasons found in international studies. Two areas seem to be particularly important in students' choice to continue or not to continue with science at secondary and tertiary level: students' experiences with school science; and their knowledge and awareness of the range of study and career options that involve science. Students' choices relate to their personal interests and

[25] Reflected in the 'Students' Valuing Mathematics' (SVM) Index, calculated by students' responses to seven questions about whether they enjoyed learning mathematics, and saw the value of mathematics for other school learning, for daily life, and for their future careers.

[26] There was a 27 scale point difference between Pākehā students with a high SVM score compared with a low SVM score, but only an 11 scale point difference between Māori students with high and low SVM scores.

[27] Insufficient data were available to report Pasifika and Asian differences.

decision-making orientations, their family background, their learning experiences – both curricular and extracurricular – and the school they attend. An intention to continue studying sciences appears to have begun, for at least some students, much earlier than senior secondary school, although other students are still very undecided at the stage of leaving school.

Many students, including those who choose to continue with science, describe school science teaching as sometimes boring, irrelevant, not people-focused, lacking in practical work, and/or requiring too much content coverage. However, research suggests that there are some students who would continue with science regardless of their perceptions of the quality of their school science learning. Internal motivations – for example, a keen interest in science, or a career orientation towards science – thus seem to be important motivators for continuing in science.

Facility in mathematics is important for students with a serious intention to continue in the sciences, yet only 64% of students were taking some form of Year 13 mathematics. The question arises as to whether students who struggle with mathematics in earlier years do not even consider carrying on with sciences, indicating the lack of success in mathematics in earlier years limits the range of students who carry on with sciences at Years 12 and 13.

Summary

This section has considered attitudes to STEM across the New Zealand landscape. The following are key points:

1. There is a large amount of Government emphasis on science, technology and innovation for New Zealand's social and economic wellbeing. This is evident in, for example, the increase in the proportion of GDP spent on research and development (from 1.15% in 2002 to 1.3% in 2010) and the alignment of Government agencies from single, small policy agencies into the Ministry of Business, Innovation and Employment.
2. In order to understand public attitudes toward science and technology, the Government funded the administration of a survey in 2002, 2005 and 2010. On the whole, science is seen to be making an important contribution to New Zealand in terms of the preservation of our environment, and enhancing our international competitiveness. However, in 2010 there was significant lower agreement for the government to fund scientific research even if we can't be sure of the economic benefits (55% agreeing or strongly agreeing, cf. 67% in 2005). Younger respondents (15-24 years) were less likely to be interested in or value science.
3. Assessment of school students' attitudes to science/mathematics via TIMSS and PISA indicates that New Zealand students report not liking learning science/ mathematics as much as their international counterparts, and see less value in learning science/mathematics. While a point of concern, this needs to be considered in light of cross-national response styles (some nations tend to report more at the extremes of scales than others). Internationally, there is also a trend for students from high-achieving countries to report being less engaged than students from lower-achieving countries.
4. The decrease in interest and engagement in science and mathematics from Grade 4 to Grade 8, as measured by TIMSS, is also common internationally, but nevertheless a cause for concern.
5. In general, Māori and Pasifika are less enthusiastic about their science and mathematics learning at school.
6. Choosing whether or not to pursue science at senior secondary school and beyond is influenced by a variety of factors, including students' experiences of learning science in and out of school, their personal interests and family background, knowledge about the range of study and career options that involve science, and

possibly mathematics learning experiences. For some students decisions about science are made very early in their school careers.

Patterns in school STEM achievement and provision

New Zealand's national curriculum (Ministry of Education, 2007) includes science, technology and mathematics as three separate learning areas, as well as English, the arts, social sciences health and physical education, and learning languages. At primary school level there tends to be a substantial amount of cross-curricular planning, whereas secondary schools continue to largely package the learning into discrete subjects – despite opportunities within the national qualifications system for greater creativity (see above).

According to TIMSS 2011, 18% of instructional time is spent on mathematics in Year 5 (cf. 23% in Australia), and 15% at Year 9 (cf. 14% in Australia). This represents an increase from an average of 148 hours in 2007 to 168 hours in 2011. However, teaching time drops to 6% for science at Year 5 (cf. 7% in Australia but 10% in the USA). At the lower secondary level, where science is taught as a discrete subject, 14% of the time is allocated to it at Year 9 (cf. 13% in Australia). TIMSS does not collect data in relation to technology, but the proportion of time spent teaching technology is likely to be similar to that of science.

STEM achievement in international comparisons

Grade 4 science achievement in TIMSS

In New Zealand, 2011 achievement at Grade 4 level was on a par with the TIMSS scale average, with NZ ranking 31st out of 50 jurisdictions (Mullis et al., 2012). However, this was significantly lower than in 2007, which itself was significantly lower than 2003. The percentage of students achieving the high and advanced international benchmarks also decreased significantly from 2007 to 2011, and the percentage of students achieving the low and intermediate international benchmarks significantly decreased from 2003 to 2011.

Achievement was higher for life science and earth science than physical science. This is likely associated with the fact that students tended to be taught by teachers confident in teaching life science and earth science than physical science.[28] Students were also more likely to have been taught life science and earth science topics than physical science topics.

There was no difference in students' achievement for knowing, applying and reasoning, although students' achievement in 'knowing' dropped significantly from 2007 to 2011. Students' achievement in life science and earth science also dropped significantly from 2007 to 2011 although there was no change in physical science achievement. 20% of students were reportedly taught by teachers who emphasise science investigation in half the lessons or more (cf. 40% internationally and 34% in Australia) despite a curriculum that emphasizes the 'nature of science' as an overarching strand.

Grade 8 science achievement in TIMSS

In New Zealand, the Grade 8 TIMSS test is administered in the first year of secondary school. Most students will therefore be taught science by a specialist teacher.
In 2011, the average scale score was significantly above the scale centrepoint. Only ten of the 45 participating jurisdictions still achieved scores that were significantly higher than this, including the United States but not Australia. There was no significant change

[28] Additional analysis of teacher confidence is provided below under 'teacher education and professional development'.

in New Zealand's achievement from the years 1995 to 2011.[29] There were also no significant changes in the percentage of students achieving the low, intermediate, high and advanced international benchmarks across 1995 to 2011 with the exception that fewer students (90%) achieved the low international benchmark in 2011 when compared with 2003 (94%).

Achievement was highest for reasoning and lowest for applying.[30] It was also highest for earth science and lowest for chemistry. This is noteworthy, since students were most likely to be taught by teachers confident teaching chemistry, and least likely to be taught be teachers confident teaching earth science. Students were also most likely to have been taught the chemistry and physics topics than life science or earth science topics. 35% of students were reportedly taught by teachers who emphasise science investigations in half the lessons or more (cf. 48% internationally, but 34% in Australia). Pākehā and Asian students tended to have higher achievement than Māori and Pasifika students (533, 533, 466 and 439 respectively). Across all ethnic groupings there were high-performing and low-performing students, with students from each grouping represented at both the higher and lower benchmarks. However, relatively few Māori students (15%) and even fewer Pasifika students (6%) were reaching the higher benchmarks compared to Asian (42%) and Pākehā students (43%) (Chamberlain & Caygill, 2012).

The 2011 TIMSS data at the Grade 8 level are overall more positive than at the Grade 4 level in both 2003 and 2007, most likely reflecting the greater emphasis on science as a specialist subject in New Zealand secondary schools in terms of both time allocated to its teaching, and teachers' more extensive science pedagogical content knowledge (see below). The positive placing of New Zealand compared to other countries suggests that, on curriculum-derived items, Grade 8 students have a robust conceptual knowledge.

Science achievement in PISA

In comparison with the relatively low TIMSS ranking of New Zealand compared with top-performing countries, our 15-year-olds achieved remarkably well in PISA science in both 2006, when science was the major domain, and again in 2009 when it was a minor domain. For example, in 2006 New Zealand was ranked 7th out of 57 participating countries and economies and only Finland and Hong Kong-China achieved mean scores that were statistically higher. We also had the second highest number of students in the top performing categories and it is possible that this positive outcome may in some part be due to the professional development undertaken by teachers (see below). However, the large proportion (14%) of students with a low level of scientific proficiency must not be ignored.

In 2009, New Zealand again achieved very highly in scientific literacy (a minor domain in PISA), with Finland still the only OECD country with a significantly higher performance. However, there was – again – a relatively large proportion of students with very low levels of scientific literacy when compared with other top-performing countries, demonstrating the very broad abilities among New Zealand students. It remains unclear whether this reflects a continued classroom emphasis on knowing knowledge rather than knowing how to find the knowledge and then how to use it, or whether it is linked to other factors such as students' low engagement in teaching and/or the PISA assessment tasks. For example, perhaps it is the assessors' choice of contexts in PISA that impact on Māori and Pasifika students' levels of engagement and achievement.

As with TIMSS, Māori and Pasifika students are over-represented in the lower tail and under-represented amongst higher performers when compared with their Pākehā and

[29] New Zealand did not participate in Year 9 TIMSS in 2007.
[30] The three cognitive domains were: knowing, applying and reasoning.

Asian counterparts. PISA results on within-school variability of student achievement reinforce the need for initiatives that support teaching and learning of diverse students who are learning within the same school environment, rather than assuming that diverse students will be in different schools or classes (Satherley, 2006).

Grade 4 mathematics achievement in TIMSS

The mathematics performance of Year 5 students has significantly improved from 1995 (TIMSS score 469) to 2011 (TIMSS score 486), although this is still lower than the TIMSS scale average (500). While it is significantly higher than 26 of the 45 participating jurisdictions, it is significantly lower than 14 jurisdictions, including Australia, England and the United States.

The spread of scores, from the 5^{th} to the 95^{th} percentiles, reduced between 1995 and 2007.[31] Most of the reduction results from an improvement in the scores of the lowest performing students, with the 5^{th} percentile increasing from 297 to 341 (Ministry of Education, n.d.). Encouragingly, the percentage reaching the low international benchmark increased from 78% (1995) to 85% (2011), and the percentage achieving the intermediate international benchmark increased from 51% to 58%. There was no significant difference in the percentage reaching the high or advanced benchmarks (Mullis et al., 2012, p. 93).

Questions related to data display were better answered than those related to number or geometric shapes and measures (Mullis et al., 2012, p. 142), as were questions relating to applying and reasoning than to knowing (Mullis et al., 2012, p. 148). This is likely related to the teaching of these topics – 90% of students had been taught data display topics, 66% geometric shapes and measures, 74% the number topics. Teachers also feel most confident / well prepared for teaching data display.

All ethnic groups demonstrated significant gains in mathematics achievement, on average, between 1995 and 2007 (see Figure 12), although the average performance of Māori and Pasifika students decreased between 2003 and 2007. While students in the ‘Other’ ethnic grouping also demonstrated a decrease from 2003 to 2007, this was not statistically significant (Ministry of Education, n.d.).

[31] 2011 data were not available at the time this report goes to print.

Figure 12: New Zealand Year 5 students' mean mathematics scores in TIMSS by ethnicity (1994-2006). (Ministry of Education, n.d.)

Year	Mean (Standard Error)					
	European/ Pākehā	**Māori**	**Pasifika**	**Asian**	**Other**	**Overall**
1994	493 (3.9)	427 (8.2)	412 (11.0)	483 (16.9)	475 (15.1)	469 (4.4)
1998	502 (5.0)	445 (7.3)	416 (15.1)	516 (9.9)	481 (14.8)	481 (5.6)
2002	506 (2.7)	479 (4.8)	464 (6.3)	500 (6.0)	504 (9.8)	496 (2.1)
2006	510 (2.1)	453 (4.4)	427 (5.1)	546 (4.9)	491 (6.0)	492 (2.3)

The booklet 'New Zealand Year 5 students' strengths and weaknesses in mathematics items from the Trends in International Mathematics and Science Study (TIMSS) 2006/2007' is intended as a resource for Year 5 mathematics teachers. It contains a selection of TIMSS 2006/07 test questions where NZ students achieved better than the international average, and examples where they did worse. Examples of resources are provided, including references to items in the Assessment Research Bank (ARBs) (see below).

Grade 8 mathematics achievement in TIMSS

The average scale score of New Zealand's Year 9 students did not change significantly from 1995 to 2011 although there is a downward trend. Like the Year 5 results, it is also significantly below the TIMSS scale centrepoint. In addition, the percentage reaching the low international benchmark decreased from 89% (1995) to 84% (2011), and the percentage achieving the intermediate international benchmark increased from 64% to 57%. There was no significant difference in the percentage reaching the high or advanced benchmarks (Mullis et al., 2012, p. 119).

Performance was better for questions related to data and chance, and number than algebra and geometry; and questions relating to applying and reasoning than to knowing. This was likely related to topics that had been taught: 96% had been taught the number topics, 76% data and chance, 68% algebra, and 72% geometry.
As with science, both high and low performers were found in all ethnic groupings. However, Asian and Pākehā students demonstrated significantly higher mean mathematics scores than Māori and Pasifika students (539, 500, 446 and 433 respectively). Asian students also performed significantly higher than Pākehā students. Māori and Pasifika were over-represented among students who did not reach the low international benchmark when compared to their respective proportions in the population (Chamberlain & Caygill, 2012).

Mathematics achievement in PISA

As with science, New Zealand performed better in PISA mathematics than TIMSS mathematics, with only five other countries/jurisdictions out of 57 scoring significantly better than New Zealand in 2006, and 10 out of 65 in 2009. (New Zealand's score was not significantly different from Australia's in either 2006 or 2009.)

National assessment

A variety of assessment information is collected in New Zealand at the national level. This includes a sampling of student achievement at Year 4 and Year in mathematics, science and technology; school reporting of student achievement against national literacy and numeracy standards (recently implemented across Years 1-8, with strong indications that schools will be required to report against these for Years 9-10 in 2014). The assessment resource banks (ARBs) are large collections of Science, Mathematics and English assessment resources made available since 1997 by the New Zealand

Council for Educational Research under contract to the Ministry of Education. Catering for Years 3-10 (7-14 year olds) they offer a substantial resource for New Zealand teachers, who are responsible for developing their own assessment systems. NCEA, described above, is the national secondary school assessment.

National Education Monitoring Project (NEMP)

NEMP commenced in 1993 at the directive of the New Zealand Ministry of Education and is tasked with assessing and reporting on the achievement of Year 4 and Year 8 students in all areas of the school curriculum on a four-yearly cycle. The aim is to provide information that 'allows successes to be celebrated and priorities for curriculum change and teacher development to be debated more effectively' (Crooks & Flockton, 2004, p. 5). Assessment is undertaken with a 2.5% random national sample, with students assessed in their schools by teachers specifically seconded and trained. This creates a significant opportunity for professional development of primary teachers, with many having reported major changes in their teaching and assessment practices (Crooks & Flockton, 2004). Because NEMP is not constrained by the need for cross-country comparisons, a relatively sophisticated administration has been developed with task instructions being given orally by teacher facilitators, through video presentations, on laptop computers, or in writing, reducing the reading and writing required by wholly paper-and-pencil assessments. Many of the assessment tasks also involve the use of equipment and supplies. Such a varied approach allows for the inclusion of tasks that interest students, so that results are more likely to represent their capabilities rather than their motivation.

As NEMP is a national monitoring project focusing on identifying shifts in achievement from Year 4 to Year 8, and within Year levels over time, student responses are reported for each question without providing averages across all items such as is reported by TIMSS and PISA. Our analysis suggests that Year 8 students are more likely to identify a greater range of variables in each context, as well as provide more detailed explanations of those variables.

Assessment Resource Banks (ARBs)

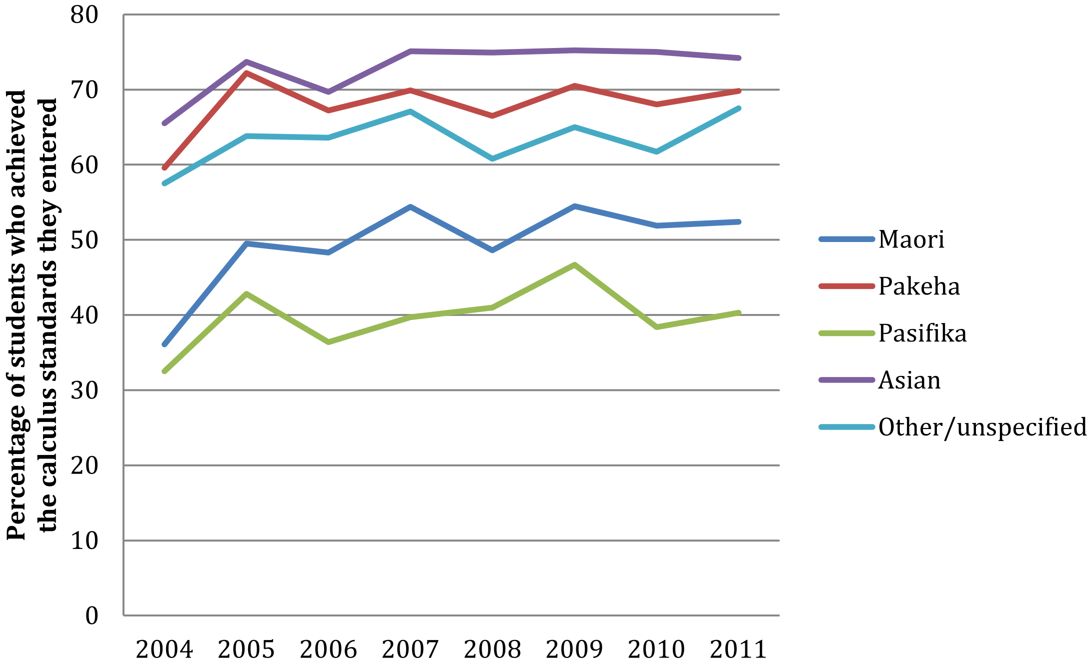
The ARBs were initially designed to assist in the development of classroom and school-wide assessment, although since 2003 their emphasis has been on supporting formative assessment – viewed as any task or interaction where 'the information gained is used to inform what happens next in the classroom' (Joyce & Darr, 2008, pp. 3-4). Many of the resources therefore include support for teaching and learning discussions, and in some cases examples of students' work. For example, the focus of the assessment is clearly described, and relevant background knowledge, diagnostic information (including misconceptions, gathered from research literature and student trials), and next learning steps tied to particular responses are provided. Each item is designed to be carried out as part of normal classroom activities to help teachers make sense of what students are saying, doing, and thinking, and to make decisions about what to do next; and to help students to reflect on their learning as they are learning.

While it is difficult to know how many New Zealand teachers actually access the ARBs, it does not seem surprising that a recent survey (Dingle & Joyce, 2011) found that over 80% of users were positive about the tasks, and found the teacher pages useful.

National Certificate in Educational Achievement (NCEA)

NCEA is the national assessment administered at Years 11-13 (NCEA Levels 1, 2 and 3), as described above, and fewer Māori and Pasifika students will attain these qualifications than their Pākehā and Asian counterparts. An analysis of individual subjects, including STEM subjects, shows similar patterns. For example, Figure 13 shows that while over 70% of Asian and slightly fewer Pākehā students who enter for external achievement standards in calculus achieve these standards, this drops to around 50% of Māori students and only around 40% of Pasifika students.

Figure 13: Percentage of students entered for calculus achievement standards who achieved the standard, reported over time[32]



Māori student outcomes in NCEA science and mathematics

Māori student exclusion from STEM subjects is laid down very early in New Zealand's secondary education system. While Māori students enter secondary school with very similar backgrounds in STEM subjects to their Asian, Pākehā and Pasifika student counterparts they are quickly excluded from gaining higher level NCEA qualifications in these subject areas. Because of the fragmented nature of NCEA, obtaining STEM subject data participation and retention rates is difficult and tedious. The Starpath Project[33] has tracked NCEA data for nine large urban secondary schools, gathering data for all the standards that make up the schools' science courses for three consecutive years and the participation of the different ethnic groups in each of the courses. The following is a case study of a large urban secondary school (n=410) with significant proportions (50%) of students from a Māori (and Pasifika) background on the roll. While each of the nine schools has variability in course structure, the patterns of allocation of students to courses, participation, retention, and achievement are similar in all.

Case study: Opportunities to learn science for Māori students in a secondary school

The biggest concern for the Head of Science and staff at this school is that the Year 9 Māori students, as a group, have entry-level literacy and numeracy knowledge and skills that were below that of the national level, and most science teachers see this as a hurdle to learning science at the senior NCEA levels. By their second year at school (Year 10) the numeracy and literacy levels of the Māori (and Pasifika) students still lag behind their Pākehā and Asian counterparts.

---

32 http://www.nzqa.govt.nz/studying-in-new-zealand/secondary-school-and-ncea/secondary-school-statistics/

33 The Starpath Project aims to increase NCEA achievement for Māori and Pasifika students and other students from low socio-economic communities, and to increase participation and success at degree-level tertiary study for these students. Funding from the private sector is matched by Government.

Faced with this dilemma, the Head of Science, along with the staff, responded by designing different courses (with various combinations of science standards) that allow for placement of students into different "learning pathways". More often than not, these pathways are perceived to be means of sorting students into highly differentiated courses that result in quite different types of learning experiences. In particular, the opportunities to learn science are invariably determined by the type of standards in the courses on offer, thereby streaming students as early as Year 10 or 11.

Student progression from Year 11 to the next NCEA level (Year 12 and Year 13) is based on choosing/being placed in a course that offers progression, and doing well in a small number of externally assessed achievement standards. In this school, science is compulsory at Year 11 and students have to meet the requirements (by the end of Year 10) to allow entry into either one of three science courses (Advanced, General or Alternative). However, the number of students doing science at Year 12 and Year 13 dropped drastically (32% at Year 12 and 18% at Year 13, out of a cohort of 314 science students in Year 11). Of the 65 Māori students who took science in Year 11, only 13 went on to Year 12 science courses, and only 6 Māori students actually left school with Level 3 qualifications in science.

Significant concerns arise from this scenario. While there is a widely-held belief in New Zealand education that students 'choose' their courses at this level, research has shown the issue to be more complex than choice, particularly for the Māori and Pasifika students and students from low SES communities (Madjar et al., 2009). For instance, as shown above, school policies dictate the design of senior Science and Mathematics courses, decisions about student placement in those courses, and other practices that impact on the level of relative success for Māori students in NCEA Science and Mathematics.

Large differences in policies exist between schools, caused at least in part by school size. Selection criteria are sought in larger schools that are quick and decisive, involving some jeopardy for students in the sense of possibly closing off future pathways to those students who may have a genuine wish and ability to go on with Science and/or Mathematics. Besides the negative washback effects of assessment and concern that assessment is driving the curriculum, at a more fundamental level, research has continued to show that there is a general lack of understanding of NCEA within schools (especially among students) and among community stakeholders – parents, employers and even universities (Hipkins & Bolstad, 2005; Madjar et al., 2009).

This brief narrative highlights the importance of providing on-going support for students from under-represented groups as they arrive at school with less than ideal academic background and preparation. In order to identify and provide focused support to these students, the science department needs to carry out extended evaluations of department structures and practices, including how they make decisions regarding placing students in courses and hence, what resources they can access and leverage. In this respect, quality data on student performance is seen as necessary to allow heads of departments and teachers to make informed decisions on teaching and learning.

Achievement in kura kaupapa Māori (KKM)

KKM was established to provide Māori students with better outcomes than are available to them in mainstream education. There is evidence that supports this claim. For example, overall pass rates in NCEA for wharekura (KKM) students are at a higher rate than Māori students in mainstream secondary schools. However, Stewart (2012) has argued that KKM students have achieved in the foundations of KKM, that is, te reo Māori (Māori language), kapa haka (Māori performing arts), tikanga marae (Māori cultural protocols and knowledge), and Ngā Manu Kōrero (Māori speech competitions). While these are important for the continuation of the language, strengthening and maintaining identity, and building Māori knowledge, they possibly contribute to concealing the reality of weak curriculum coverage in wharekura in particular. For example, almost 50% of students graduating from KKM with any national qualification (NCEA Level 1, 2 and/or 3) have no credits in science or pūtaiao (KKM science learning area). This is not as good as Māori students graduating in STEM related subjects from mainstream schools. Stewart (2012) argues that the limiting factor contributing to this outcome is an issue of language medium in teaching pūtaiao – the immersion pedagogy for language acquisition that guides the practice at the earlier KKM schooling levels works against learning of scientific knowledge and language at the upper levels of secondary education when the immersion practice is 'enshrined by cultural essentialism' (Stewart, 2012, p. 60).

It is important to note here that the continuing disparities in NCEA results do not in any way disparage KKM and the very successful NCEA results their students have achieved. The boost to the students' self-belief and confidence is not to be underestimated, and there is a deepening of Māori identity. The other 'success' KKM has achieved is that of the involvement of whānau/family in their children's education. Stewart (2012) has suggested that the most important thing about KKM may be its identity where it is normal to be Māori, and for this reason alone it attracts significant Māori parental and whānau involvement.

Teacher education and professional development

As in many other countries, New Zealand offers multiple pathways into teacher education: A three-year degree for early childhood and primary teachers; a four-year honours degree for early childhood and primary teachers; a one-year graduate diploma for early childhood, primary and secondary for those who already have an undergraduate degree; a four-year double degree for early childhood, primary and secondary. 97% of teacher education takes place within the nation's universities, most of which offer English, bilingual and full-immersion Māori programmes.

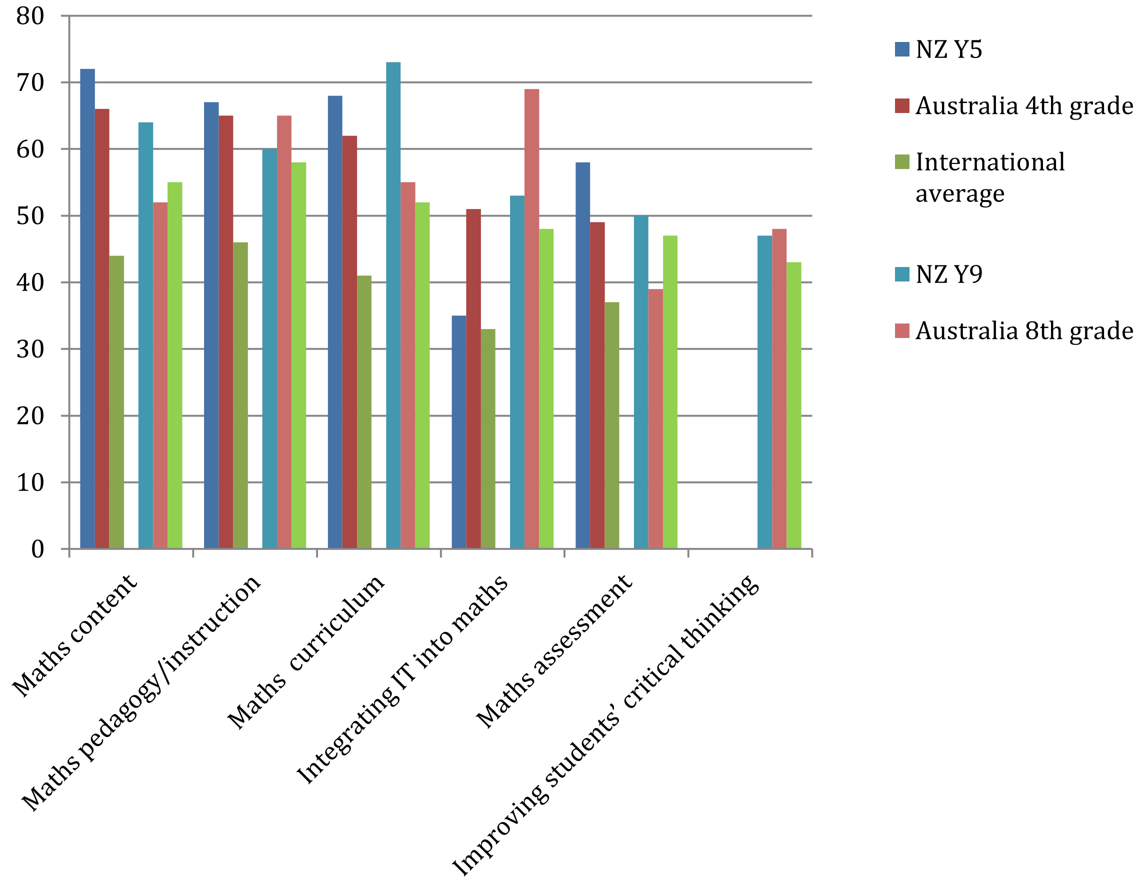
In the primary degree programme, the first year includes modules on each of the curriculum learning areas, including mathematics, science and technology. The weighting for each of these is approximately 6% of the course load. Mathematics is compulsory at level 2 with two other subject options (which could be science and/or technology) available; at level 3 there is space for only one subject option. The graduate diploma for primary teaching has papers focused on general pedagogy, curriculum theory, and content areas. There is less emphasis on content areas in the secondary teaching diploma because of the degree qualifications of the candidates.

To graduate, students need to meet the New Zealand graduating teacher standards related to professional knowledge (how to teach, knowing about learners and learning, influences on teaching and learning), professional practice (planning for safe, high quality teaching and learning environments, evidence of how to promote learning), and professional values and relationships (positive relationships with learners and learning communities, being committed members of the profession). Teacher registration is a two year process during which teachers have a 0.8 teaching load in the first year, and they should have access to internal and external mentoring and professional learning support. Final registration with the Teachers Council is through attestation by the principal. Interestingly, fewer teachers have postgraduate qualifications than elsewhere in the world: According to TIMSS (2011), 19% of New Zealand's Year 5 students, 35% of Year 9 maths students and 51% of Year 9 science students were taught by teachers with a postgraduate university degree (cf. 65% and 64% for Australia) (Mullis, Martin, Foy, & Arora, 2012; Mullis, Martin, Foy, & Stanco, 2012).

Professional development in mathematics

Professional development in mathematics, according to TIMSS 2011, is higher at primary level than secondary except for professional development relating to the mathematics curriculum and integrating IT into mathematics (see Figure 14). In general, more TIMSS students were taught by teachers who reported receiving professional development than Australia or internationally, although more Australian teachers appear to have received professional development related to integrating IT into mathematics. The higher provision of professional development overall is possibly connected with the New Zealand Government's current priority on numeracy and literacy standards – part of which has involved a shifting of professional development funding from other curriculum areas (including science and technology) to numeracy and literacy. Important to note, too, is that while learning associated with numeracy is a subset of mathematics learning, it does not represent mathematics learning in its entirety.

Figure 14: Percentage of students taught by teachers who reported participating in mathematics-related professional development (Mullis, Martin, Foy, & Arora, 2012, pp. 298, 300)



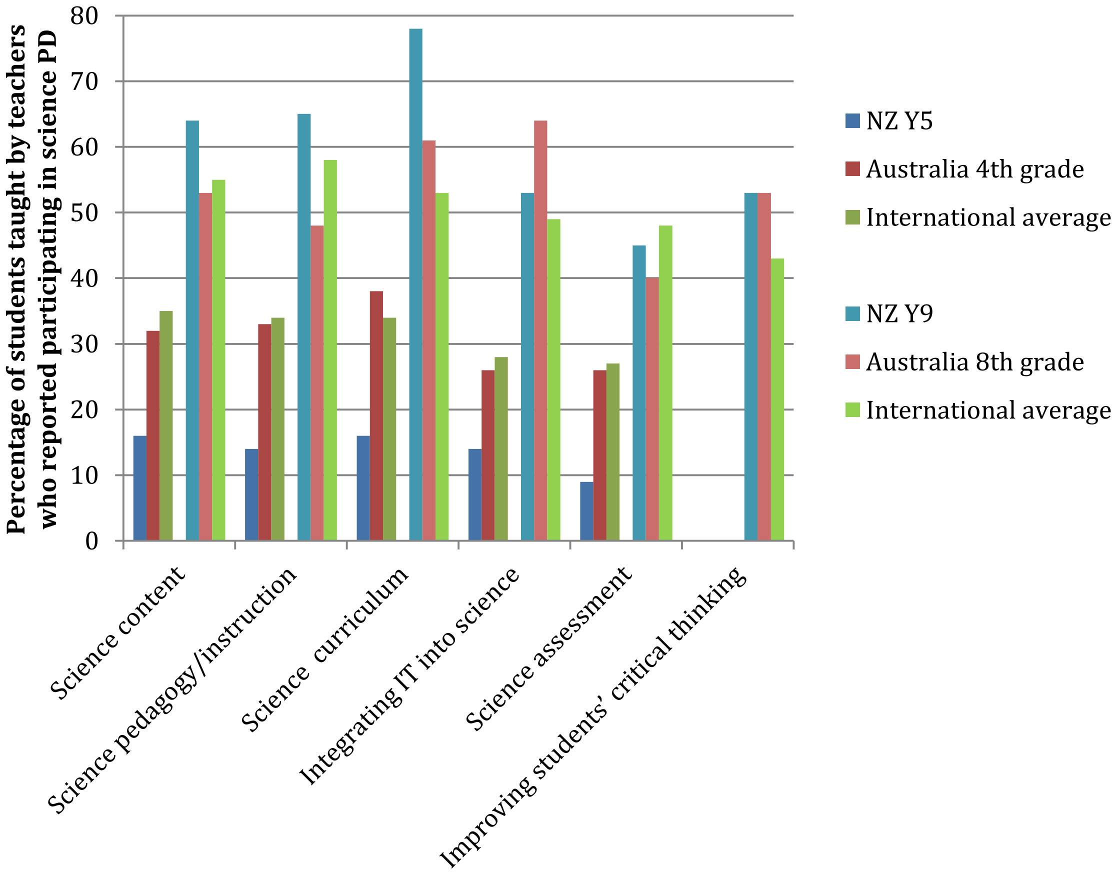
Despite the relatively high provision of professional development in mathematics, primary teachers reported feeling less confident than their Australian counterparts teaching mathematics: 63% of NZ's TIMSS Year 5 students were taught by a teacher who is 'very confident' compared with 76% of Australian students. This increased to 73% at Year 9 (cf. 78% in Australia).

Professional development in science

With respect to the background of science teachers, only 13% of the 2011 TIMSS Year 5 students were taught by a teacher with primary education qualifications *and* a major in science (compared with the international average of 25%). In addition, primary students' teachers were less likely to have participated in professional development related specifically to science than their international counterparts (see Figure 15). Science-specific professional development was much more widely available at secondary level, most likely associated with the process of aligning NCEA achievement standards and the curriculum.

Unfortunately, there is presently a move towards reduced funding for secondary-level professional development related directly to science (or technology), with contracts for subject-based professional development having been replaced by more generic contracts related to Government priorities, including targets for NCEA achievement, achievement of Māori and Pasifika students, and one-off professional development days related to the revised NCEA achievement standards.

Figure 15: Percentage of students taught by teachers who reported participating in science-related professional development (Mullis, Martin, Foy, & Stanco, 2012, pp. 298, 300)



Professional development in technology

Technology education was first mooted in the National Government's 'Achievement Initiative' in 1991. The policy framework was developed in 1992/1993, with a draft curriculum for consultation developed in 1993 and a final curriculum published in 1995. Coinciding with this release, the Government invested significantly in technology teacher professional development in the mid to late 90s. One of the gaps that became apparent was that many technology teachers did not have a degree-equivalent qualification. This led to the development of new degree programmes that included courses from both education and engineering faculties. Entry points into these programmes are determined on a case-by-case basis in order to recognise prior learning and/or qualifications. Professional development in technology education also received a significant amount of funding from the Ministry of Economic Development through the Growth and Innovation Framework-Technology Initiative (Dinning, 2007). This offered relatively stable funding with a ten-year lifespan (until 2013), which has allowed the initiative to be strategic on a level unprecedented in previous attempts to provide teacher professional development support for technology education in New Zealand (Jones & Compton, 2009). While funds were appropriated for support of senior secondary students (Years 11–13), work with students from Years 7–13 has been included on the basis that coherent programmes developed across this range would make gains in the senior secondary sector more likely.

The GIF-Technology funding includes:

- the development of an online resource (technology.tki.org.nz, formerly www.techlink.org.nz) which showcases examples of contemporary teaching and learning in technology and provides curriculum support for educators in their ongoing planning, implementation and review of teaching and learning programmes;
- the Technology Beacon Practice Project, identifying and documenting case studies of exemplary classroom practice;
- a Technology Leader Support Programme;
- the 2007 Curriculum Support Package, providing an explanation of and guidance for the 2007 technology curriculum; and
- the appointment of a National Technology Professional Development Manager.

A joint learning community of teacher educators, as well as separate in-service and pre-service teacher educator learning communities has resulted in a growing level of shared understandings and a collaborative and supportive network between regions and institutions. Unfortunately there is as yet no substantive evaluation of the initiative or its components.

General professional development programmes

As indicated above, Government-funding of professional development has in recent years been channelled away from subject-specific professional development except for where it has related to the alignment of the achievement standards (senior secondary level) with the revised Curriculum released in 2007.

By and large, funding has instead been directed to numeracy and literacy initiatives, generic professional development in IT skills, and professional development targeting increased engagement and achievement of so-called 'high priority learners' (Māori, Pasifika, and special-needs students).

Data use in schools

An audit conducted in 16 secondary schools on their data systems for supporting teachers in improving learning outcomes found that schools were rich in data but lacked a systematic and coherent approach to school-wide data collection, analysis, interpretation and use (Irving & Gan, 2012). A recurring theme is the limitation of the current Student Management System (SMS) to provide timely and relevant data that is suitably accessible and comprehensive for teachers to inform teaching and learning. In addition, the lack of historical data in the SMS is seen as a huge hurdle to a more in-depth analysis of longitudinal data on student performance over time.

Follow up interviews with the Heads of Science in selected schools indicated that besides the availability of data, teachers need specific knowledge and skills to identify the relevant data that will help to change their current practices as well as inform future learning. The Heads of Science also commented that there is a lack of appropriate science diagnostic assessments at junior secondary level. School-based assessments tend to be variable, and the predominant asTTle assessments, though useful for identifying literacy and numeracy skills, are limited on assessing students' science content and process skills. The transition from junior science to NCEA science courses appears to be disjointed, and Heads of Science were concerned with finding better ways to measure student progression in science within and across the levels and identifying specific learning needs of under-represented groups of students (i.e., Māori and Pasifika students).

School employment of STEM teachers

Schools can have difficulty employing teachers for mathematics and to a lesser extent science and technology. For example, 44% of TIMSS 2011 secondary students attended schools where the principal reported that vacancies for mathematics teachers were somewhat difficult or very difficult to fill (Mullis, Martin, Foy, & Arora, 2012, p. 236). However, only 22% were at schools where the principal reported that vacancies for science teachers were somewhat difficult or very difficult to fill (Mullis, Martin, Foy, & Stanco, 2012, p. 236).

As a proportion of entitlement positions, vacancies in 2012 were slightly higher in rural areas, schools with the highest proportion of Māori students (relative to other schools) and low decile schools (Lee, 2012).[34] Mathematics and statistics vacancies made up the greatest proportion of all vacancies in secondary school vacancies (19% of all school vacancies) in 2012, although a higher demand for teachers in this subject area is expected as mathematics is a core subject offered in all secondary schools. Vacancies in science subjects made up the second highest proportion of vacancies (15%). Vacancies in technology subjects decreased from 10.5% in 2011 to 5.2% in 2012. Teach NZ offers in the region of 400 scholarships depending on the areas of greatest demand. For 2013 these were targeted exclusively at those with te Reo Māori (Māori language) skills or, at the ECE level, knowledge working with Pasifika communities. However, in the recent past there have been scholarships targeting future science and technology teachers, including 'career changers'.

School-community links

The New Zealand Curriculum (Ministry of Education, 2007) includes as one of its eight principles 'community engagement' and strongly encourages connections between the school and the wider community. Engagement with the science or technology community of practice is therefore encouraged. Establishing such links is seen to be advantageous in terms of both increasing student engagement by, and enhancing their learning.
A recent report commissioned by the Ministry of Education (Bull, 2012) highlighted the large number of initiatives that exist to connect schools with scientists, ranging from 'one-off' events (e.g., open days, road shows, scientists visiting schools) to on-going

[34] Decile 1 represents the lowest 10% of parental income in a school zone (based on national census date), with decile 10 representing the highest 10% of parental income.

work between schools and scientists/science organisations (such as the mentoring of school students by scientists or tertiary science students, internships, scientists working alongside schools in local projects, and a few scientific institutions that have their own educators and classrooms). The Ministry of Business, Innovation and Employment funds a fellowship scheme for teachers to spend two terms in a research or technology environment.

The initiatives focus variably on encouraging more students to choose scientific careers, and better engaging *all* students in their science learning. Resourcing was a concern for the majority of the initiatives. Universities, Crown-Research Institutes and other science research organisations often reported funding the initiatives themselves. Other initiatives are funded through the Ministry of Education (e.g., through its Learning Experiences Outside the Classroom – LEOTC – funding), or by local and regional councils, business and philanthropic groups, and community trusts. In general, funding appears to be more readily available for initiatives targeting Māori and Pasifika students.

In terms of individual teachers identifying and contacting science/technology experts, Futureintech (www.futureintech.org.nz) is a Government-funded initiative of the Institute of Professional Engineers NZ (IPENZ). Central to this work is the employment of eight regional facilitators charged with linking schools with local industries, including the recruitment of industry-based ‘ambassadors’ who are trained by the facilitators to work in schools, supporting science and/or technology projects and providing a real-world perspective.

The New Zealand Biotechnology and Science Learning Hubs (www.biotechlearn.org.nz and www.sciencelearn.org.nz) offer an alternative approach to schools seeking access to the science/technology communities (Buntting & Jones, 2012). These web-based resources are funded by the Ministry of Business, Innovation and Employment as part of their ‘Engaging New Zealanders with Science and Technology’ strategy. Launched in 2005 and 2007 respectively, funding for the Biotechnology Hub was initially provided in response to the New Zealand Biotechnology Strategy (Ministry of Research, Science and Technology, 2003), which signalled three goals to support the economic development of the biotechnology sector:

- to build understanding about biotechnology and constructive engagement between people in the community and the biotechnology sector;
- to manage the development and introduction of new biotechnologies with a regulatory system that provides robust safeguards and allows innovation; and
- to grow New Zealand’s biotechnology sector to enhance economic and community benefits.

A key action area identified to achieve the first and third of these goals was to enhance biotechnology education in New Zealand at all levels, including the school sector. The aim of the Hubs, therefore, was to make the work of New Zealand biotechnologists and scientists more accessible and relevant to New Zealand school students. The content is developed by a specialist team of teachers, education researchers and multimedia designers who liaise extensively with practising scientists/technologists.

In October 2012, over 2,400 teachers were registered users of the Biotechnology Hub, which recorded 23,153 unique visitors to the site during the month. The Science Learning Hub had over 3,500 registered users of the Science Learning Hub, with 132,439 unique visitors recorded during October (Di Hartwell, personal communication, 9 November 2012). Key to the sites’ success has been the development of content specifically for educational purposes, presented in ways that are intended to give it coherence within an educational setting. Secondly, the selection of real-life contexts is based on a reflection of New Zealand research as well as what is likely to be of interest and relevance to students. Within this, the human aspects of science and technology

(Aikenhead, 2005, cited in Buntting & Jones, 2012) are emphasised, including the people and stories of science and technology, as well as the ways in which science and technology relate to everyday life. Thirdly, quality assurance processes ensure the trustworthiness and credibility of content. Finally, the resource provides the school community with virtual access to the science/technology community in ways that have hitherto been difficult to establish and maintain, and as such the initiative has been enthusiastically embraced by the science/technology community.

School-community links improving outcomes for priority learners (Pasifika)

'Healthcare Heroes' is an example of a school-community partnership supporting the learning of Pasifika students. The collaboration, between 15 Auckland secondary schools and the Pasifika Medical Association (PMA), aims to engage students in science and increase the number of Pasifika students entering and completing health science degree courses at the tertiary level. Three secondary schools were selected to set up Health Science Academies within their schools, providing an integrated science course with extra instructional resources (e.g., science texts, netbook computers and models of the human body) geared towards learning health science related knowledge and skills and a case study of one of these schools is presented below.

A case study of a Health Science Academy in College X

College X is a decile 1 secondary school in Auckland with a large enrolment of Pasifika students (75%). The Health Science Academy at College X caters mostly to Pasifika students and is funded by the Pasifika Medical Association (PMA) through the Ministry of Health Pacific Provider Workforce Development Fund with additional support from two philanthropic trusts. The PMA provides support through professional development of teachers, support to the parents of the Academy students (information evenings); support through exam and study skills workshops; and is supplying the Academies with science teaching resources (e.g., brain and eye models, torsos etc.), science texts and netbook computers to facilitate aspirational and inspirational science teaching, learning and engagement. Students selected for the academy (n=22) stayed together as a cohort for all of their science classes in 2011 (except for their elective options) and meet every day for 20 minutes "tutor time" with their tutor teacher who is the Health Science Academy teacher. The Academy students have continued through to NCEA Level 2 in 2012 and in 2013 the students will be completing NCEA Level 3 and University Entrance. In 2012 another Year 11 cohort (n=21) joined the Academy pipeline and in 2013 a third Year 11 cohort will commence.

Instead of the traditional structure of taking one integrated general science course at Year 11, Academy students take two science courses. Both are of a high quality (where students are entered for externally assessed achievement standards) and have been chosen by the Academy teachers to prepare students with the skills and knowledge required to progress into senior science subjects (NCEA Level 2 and 3 physics, chemistry and biology). The impact of the Health Science Academy on Pasifika students' participation in science at College X has been profound. At NCEA Level 2, there was a total increase of 61 additional Pasifika students taking Science (either physics, chemistry and biology) between 2010 and 2012.

In the Science achievement standards, the Academy pass rates were comparable or better than the national pass rates. The biggest gains in the results were made in the General Science achievement standards. Out of the 11 achievement standards, 10 standards outperformed national rates for Pasifika students and three standards outperformed all student cohorts. In addition, the Academy makes a significant contribution to the participation of Pasifika students in science achievement standards nationally – in some standards, the Academy cohort made up the majority of Pasifika candidates nationally.

Summary

In the first part of this section, patterns in school STEM achievement as measured by TIMSS and PISA have been presented, along with discussion about Māori and Pasifika student achievement in NCEA, the national secondary school qualification. Aspects related to the provision of STEM, including teacher education and professional development, employing STEM teachers, and school links with science communities are also discussed.

The following are key points:

1. According to TIMSS data, less time is spent on mathematics instruction at primary school level than in Australia.
2. New Zealand's Grade 4 students are at or below the TIMSS scale average in mathematics and science. While mathematics achievement has improved slightly from 1995 to 2007, science achievement has dropped.
3. In contrast to the Grade 4s, New Zealand's Grade 8 (Year 9) students do better than the TIMSS scale average in mathematics and science. As with nearly every other international and national measure of achievement, Pākehā and Asian students tended to have higher achievement than Māori and Pasifika students.
4. New Zealand's 15 year olds do extremely well in scientific literacy as measured by PISA although the large proportion of students with very low levels of scientific literacy is cause for concern. New Zealand students also do well in PISA mathematics.
5. At the national level, trend data for Year 4 and Year 8 students is collected via the National Education Monitoring Project. The recent introduction of national literacy and numeracy standards for Years 1-8 will lead to a large data resource, although the validity and reliability of these data are yet to be determined. (2012 was the first year when all schools reported these data nationally, using a variety of assessment tools.)
6. The Assessment Resource Banks (ARBs) are a significant teaching and assessment resource for mathematics and science for Years 3-10.
7. Māori and Pasifika tend to be under-represented in all NCEA achievement data. Some schools are responding to low literacy of Māori and Pasifika students by creating alternate science options, but this has implications for the subsequent progression of students into science and non-science pathways.
8. Although the Kura kaupapa Māori system offers Māori students and communities significant advantages in terms of their cultural identity, fewer students do pūtaiao (science) achievement standards than in English or bilingual schools.
9. There is perennial concern about the amount of time spent on science and technology in the education of primary teachers, although this is common around the world. Fewer New Zealand teachers appear to hold postgraduate qualifications than elsewhere in the world.
10. Primary teachers are likely to receive more professional development in mathematics than in science or technology. This is likely to be exacerbated with the current Government emphasis on numeracy and literacy, with professional development funding being channelled into these areas.
11. Secondary teachers appear to have greater access to professional learning opportunities in science when compared with their international counterparts. This is likely due to the recent revision of the curriculum and subsequent changes to the achievement standards.
12. The GIF-Technology funding represents a unique programme of funding for a specific subject area – technology – and has allowed the establishment of a range of national and localised initiatives. Unfortunately there is as yet no substantive evaluation of the initiative or its components.

13. Vacancies for mathematics teachers, and to a lesser extent science and technology, continue to be more difficult to fill than many other subject areas, particularly in low decile and rural schools.
14. A range of schools have established links with scientists and/or science organisations, although resourcing of these initiatives is a perennial challenge. The Government funds some of these, for example:
    a. Learning Experiences Outside the Classroom (LEOTC);
    b. a teacher fellowship scheme where teachers spend two terms working in a research organisation;
    c. Futureintech, with full-time paid facilitators who recruit industry-based ‘ambassadors’ and connect them with schools; and
    d. the Science and Biotechnology Learning Hubs.
15. Initiatives targeting Māori and Pasifika students tend to be better supported than more generic initiatives.

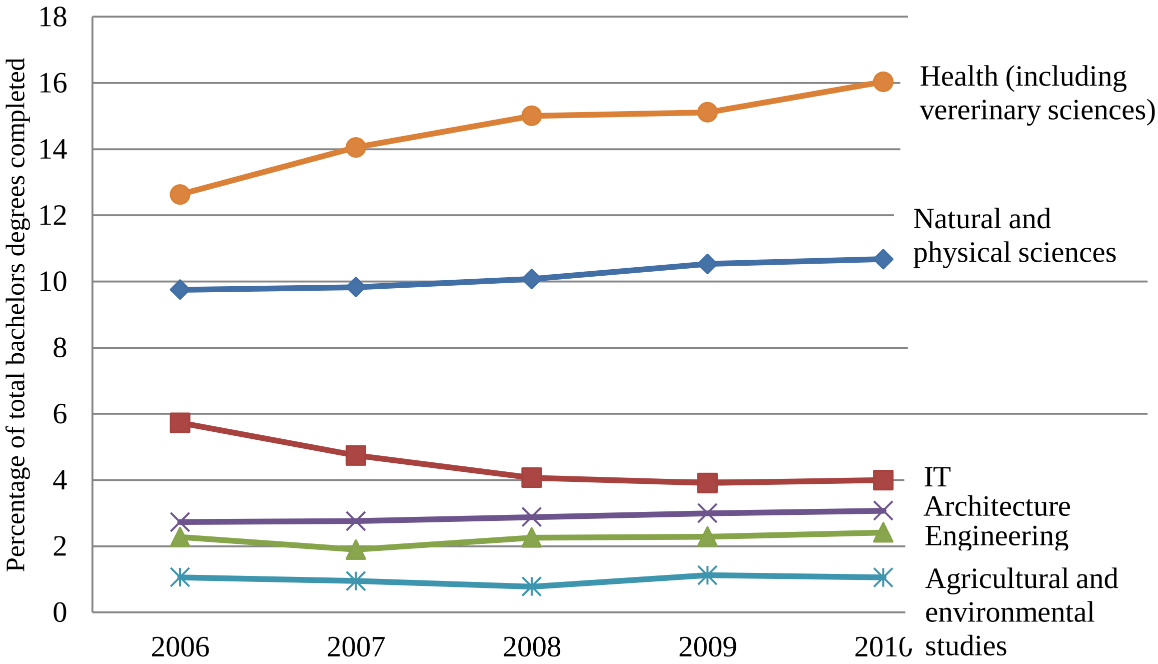
STEM uptake at the tertiary level

As pointed out in the introduction, STEM is taken in this report to include natural and physical sciences (including mathematics), engineering, information technology, health (including veterinary sciences), architecture, and agricultural and environmental and related studies. These categories are used in the annual collation of national education data at the tertiary level.

Comparisons of STEM-related qualifications

Although there are minor variations in undergraduate and postgraduate qualification completion over the 2005-2010 period, there is no obvious decline or increase in both absolute and relative terms. At the undergraduate level there appears to be a slight increase in health, and a slight decrease in information technology (see Figure 16).

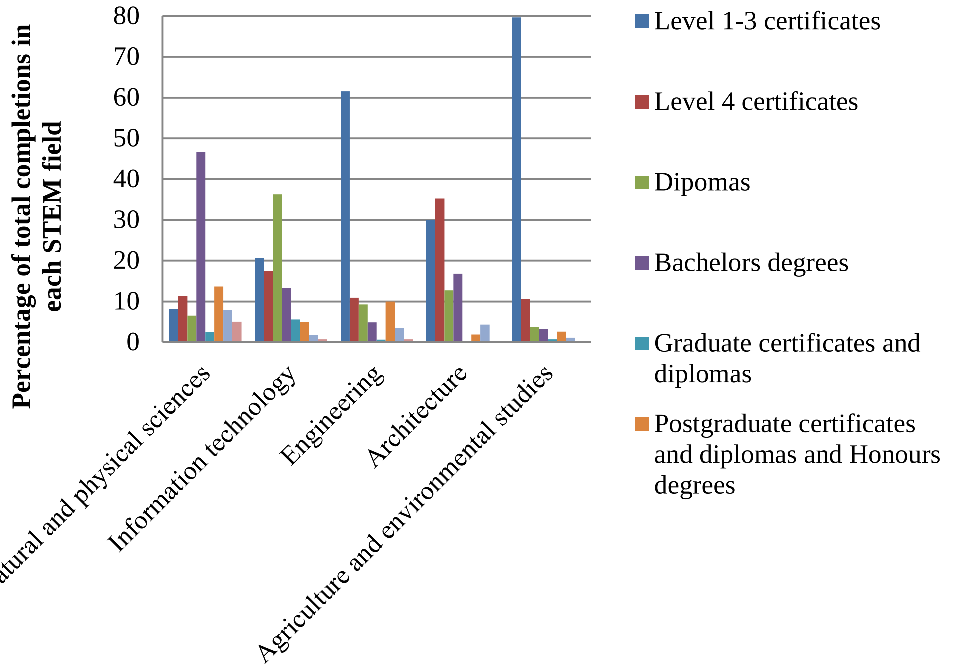
Figure 16: Percentage of students completing bachelor degrees in STEM-related fields from 2005-2010[35]
(2005, n=23,690; 2006, n=23,360; 2007, n=23,200; 2008, n=24,320; 2009, n=24,020; 2010, n=22,760)



[35] http://www.educationcounts.govt.nz/statistics/tertiary_education

Figure 17 represents the types of qualification most common in each STEM-related field: for natural and physical sciences, 47% of the qualifications were awarded at the degree level, and 13% represent a research degree (Masters or doctoral level). In contrast, 62% of engineering qualifications were only Level 1-3 certificates, with only 5% of engineering qualifications representing bachelors degrees.

Figure 17: Qualification in STEM-related fields by type of qualification (2010)[36] (n=5,200 natural and physical sciences; 6,840 information technology; 11,290 engineering and related technologies; 4,170 architecture; and 7,290 agricultural, environmental and related studies)

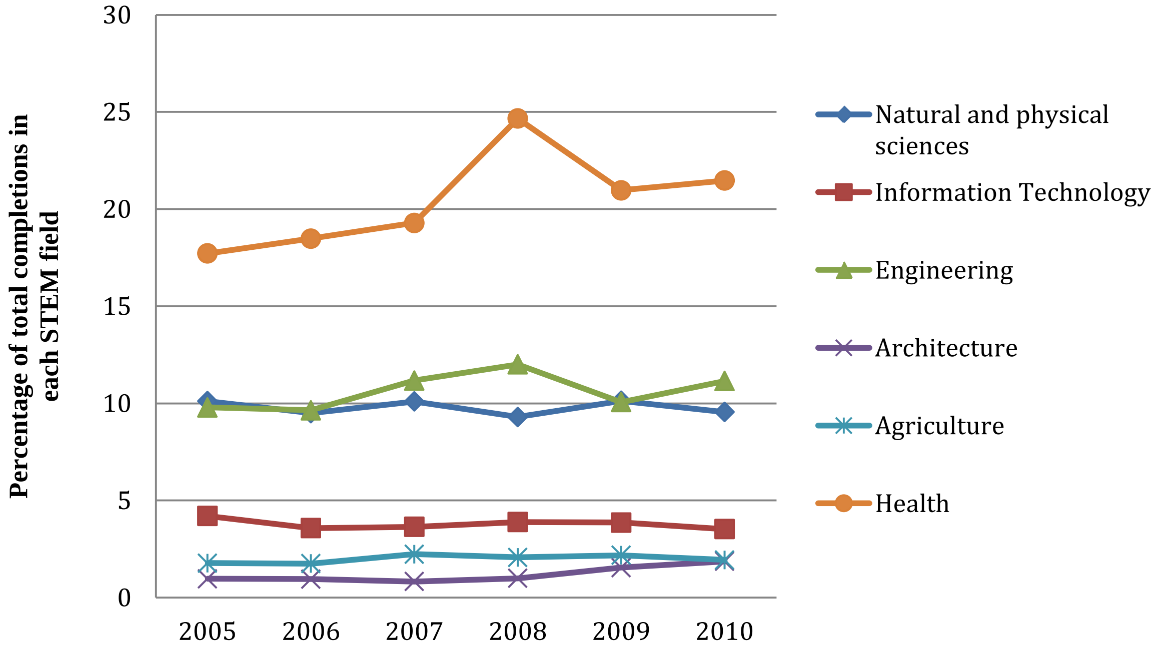


In recognition of the potential contribution of STEM to the growth of the economy, the New Zealand Government has increased its funding to Universities for science (2%) and engineering (8%) cost categories but not increased this component of funding for other subject areas. However, one policy lever does not a pipeline make, and Jones (2012) has pointed out that it is also important to find ways to encourage able students into these subject areas, as well as creating an environment where scientists and engineers are valued within society.

Figure 18 shows the general increase in the number of candidates completing postgraduate qualifications in health, with postgraduate qualifications in engineering and natural and physical sciences sitting at around 10% of the qualifications in each of these fields. Less than 5% of qualifications in IT, architecture and agriculture are at the postgraduate level.

Figure 18: Percentage of students completing postgraduate qualifications in STEM-related fields from 2005-2010 (includes postgraduate certificates and diplomas, honours degrees, masters degrees and PhDs)[37]
(2005, n=12,360; 2006, n=13,690; 2007, n=12,080; 2008, n=13,760; 2009, n=14,210; 2010, n=14,440)

36 http://www.educationcounts.govt.nz/statistics/tertiary_education
37 http://www.educationcounts.govt.nz/statistics/tertiary_education



As with nearly all other measures of academic 'success', Māori and Pasifika people are proportionately less likely to hold bachelors degrees (see Figure 19). Current literature indicates that prior achievement is a major barrier to entering university for many Māori school leavers, who are less likely to transition into degree-level study than other ethnic groups. Of all 2004 school leavers, 50% of Asian students and 33% of European/Pākehā students began a bachelor's degree, compared with 13% of Pacific students and 11% of Māori students (Ussher, 2007).

The disparity in transition rates between ethnic groups is greatly reduced when only students eligible to enter university are compared, although Māori are still less likely to enroll in a bachelors degree (Loader & Dalgety, 2008; Ussher, 2007). For example, of students who left school with University Entrance (UE) in 2004, 82% of European/Pākehā students moved on to degree-level study, compared with 81% of Asian students, 77% of Pacific students and 70% of Māori students (Ussher, 2007). It is in this context that Earle (2007) comments on the relationship between school success and tertiary study:

> In order to make a significant change in the number of Māori attaining degrees, the most important change would be to increase the number of Māori secondary school students achieving University Entrance or better. This remains the major constraint on success. It limits the number of younger Māori who can enter degree studies. (p. 3)

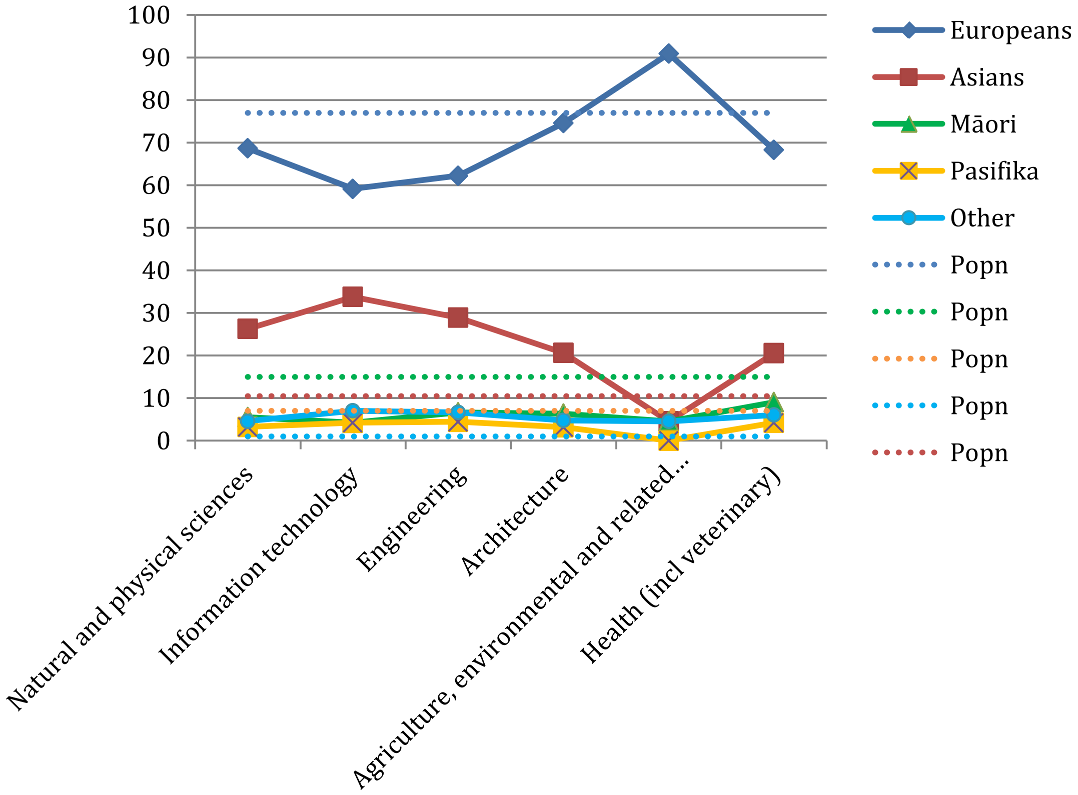
Prior academic achievement is also an important influence on the success of Māori students who do enter university, with first year Māori students less likely to pass their degree-level courses than non-Māori. They are also less likely to continue into the second year of an undergraduate degree (Earle, 2008a; Scott, 2008). In addition, it is important to note that factors other than school achievement, such as finances and whether students are part-time or full-time, may have more influence on tertiary achievement for Māori than for non-Māori (Scott, 2008).

Figure 19: Bachelor degree completion in STEM-related fields by different ethnic groups, 2010[38] (Dashed lines represent the 2006 ethnic distribution in the general population[39])

---

[38] http://www.educationcounts.govt.nz/statistics/tertiary_education

[39] http://www.socialreport.msd.govt.nz/people/ethnic-composition-population.html



Tertiary/institutional outreach into schools

Over the last decade or so there has been an increasing number of STEM outreach programmes from universities (and sometimes other tertiary or research institutes) to schools, and in particular secondary schools. The purpose of these programmes is usually to increase student confidence and competence in STEM subjects and raise awareness of opportunities for further study and careers in these fields. Some such programmes are implemented only for a finite period of time while others have taken the form of educational resources, often with a Māori and/or Pasifika component, developed by a range of Government agencies, universities, Crown Research Institutes (CRIs), and large industries such as forestry.

The number of support programmes is large. We have decided to provide a case study of one large New Zealand university which underwent a review in 2011 of its science-based outreach programmes[40] to give an idea of the number and extent of the programmes.

Case study: University of Auckland (UoA)

The science outreach programmes at the UoA are linked to four broad purposes: motivational, mentoring and/or tutoring, information giving, and, to a lesser extent, capacity building (sometimes for teachers and students). Programmes act as recruitment vehicles as well.[41] Some programmes are targeted specifically at priority learners (Māori, Pasifika, and students from low SES backgrounds).

There are 24 programmes that specifically target Māori and Pasifika students. While some of the programmes are faculty specific, some are collaborative between faculties

[40] Four faculties are involved: Faculty of Science (including Mathematics), Faculty of Medical and Health Sciences, Faculty of Engineering and the Faculty of Education. The University's Equity Office is often involved as well.

[41] Because of the major focus on promoting the University and its courses, rather than on capacity building within schools, this case study is presented here, in the section on STEM uptake at tertiary level, rather than in the earlier section on school-community links.

and the university's Equity Office. Furthermore, many of the 24 programmes are broader than just being science-related and a number target recruitment.

Individual faculties also offer outreach programmes specific to their fields. The largest and most cohesive and comprehensive science-based outreach programme is located in the Liggins Institute in the Faculty of Medical and Health Sciences at the UoA and is called the LENScience Programme (Liggins Education Network for Science). It is also the only programme that can be classified as a specific science-based capacity building programme that targets both teachers and students. Examples of the diverse ways in which they connect with secondary schools include one day on-site programmes for students in Years 7-13; resources for the NZ curriculum (Years 7-13); teacher professional development, including a 4 week programme where teachers work alongside scientists in an established research team (in conjunction with the Royal Society); a suite of programmes using ICT's (e.g., satellite TV, video conferencing, called LENScience Connect) to reach a range of geographical locations; student-scientist mentoring and student research modules (mainly related to the Royal Society's Crest awards, NCEA achievement standards and the Junior scientist award extension programme); a summer school programme; and the Māori and Pasifika student initiative targeting improved educational outcomes in science and pūtaiao. Unfortunately, while the programme offers some promise at the time of writing this report, there is no programme evaluation available to indicate its effectiveness.

Other outreach programmes take the format of competitions, training camps for competitions (e.g., Olympiads), open days, careers evenings, visits to schools, newsletters, participation in parent and careers evenings at schools, public lecture invitations, posters, summer schools, mentoring, tutoring, young scholar programmes, teacher days/fieldtrips, building resources or helping schools develop resources (e.g., DVDs, educational software), courses designed for teachers (e.g., subject-specific Masters degree programmes for teachers), research carried out in schools (e.g., Government-funded TLRI projects[42]), working with students and teachers on local research projects, help with science fairs, working in primary schools to develop science curricula, and professional development days for teachers. In addition, a number of faculties and departments offer scholarships for various events (e.g. to help students get to summer schools).

Many universities and other institutions offer similar programmes to a greater or lesser extent. The biggest concerns for *all* outreach programmes is that they are not designed to target a specific need, nor are they evaluated for effectiveness. This suggests the programmes are more about recruitment and gaining the students' and school's confidence (and preferences). It would be useful to see a more cohesive and comprehensive approach by all concerned.

Ongoing support for Māori and Pasifika students

Besides reaching out to school students, there are a range of initiatives at the tertiary level which provide support for Māori and Pasifika students in order to increase their participation and success. From a STEM perspective, one key initiative is Vision 20:20 by the University of Auckland. Vision 20:20 is the Faculty of Medical and Health Sciences' commitment to increase the number of Māori and Pacific health professionals to 10% of the health workforce by the year 2020. It has three components and is coordinated by Te Kupenga Hauora Māori (Department of Māori Health).

Māori and Pacific Admission Scheme (MAPAS)

[42] The Teaching and Learning Research Initiative (TLRI) is a small pool of Government funding that researchers can apply for annually to carry out collaborative education research in areas of their own and national interest. Six projects were awarded in 2013.

One of the components of Vision 20:20 to support Māori and Pacific learners in science at the tertiary level is the Māori and Pacific Admission Scheme (MAPAS), available to Faculty of Medical (Bachelor of Medicine and Bachelor of Surgery and Bachelor of Pharmacy) and Health Sciences (Bachelor of Nursing, Certificate in Health Sciences, Bachelor of Health Sciences) applicants with indigenous Māori or Pacific whakapapa/ancestry. The programme aims to provide a supportive environment and structure where students, their whānau and staff are committed to academic achievement within a Māori or Pacific context.

The support offered by MAPAS is divided into three categories – admission support, academic support and pastoral support. Admission support opens up opportunities for students who have Māori or Pacific whakapapa/ancestry and who are citizens or permanent residents of New Zealand to apply for degree courses in medicine and health science. Depending on the course of study, eligible applicants will need to go through a series of interviews and satisfy the academic requirements stipulated. Successful applications receive academic support which includes additional group tutorials, specific study space and computer labs, study retreats, homework and pre-exam study support, and guidance on forming study groups. Academic staff and mentors work with their MAPAS students to ensure that learning takes place in a culturally appropriate way (which may include whānau kai or meals and hospitality, marae/fale overnight stays, wānanga, and use of karakia/prayers and the inclusion of extended whānau). MAPAS students also receive pastoral support in the form of peer/whānau support through regular cohort lunches and wānanga, MAPAS “Freshers” wānanga, MAPAS-specific orientations, attendance and progress tracking and scholarships information and application support

Certificate in Health Sciences

The second component of Vision 20:20 is the CertHSc, a one-year foundation programme aimed at bridging Māori and Pacific students from secondary school study or from the community into programmes offered by the Faculty of Medical and Health Sciences. In particular, the CertHSc is focused on increasing the number of Māori and Pacific students completing courses in healthcare and health sciences so that they will eventually enter the workforce as successful health professionals. The programme provides students with a broad foundation in health science and offers a wide range of subjects from population health, biology and mathematics, to academic professional development.

Whakapiki Ake Project (WAP)

The third component of Vision 20:20 is the Whakapiki Ake Project, a recruitment project that actively engages with Māori enrolled in secondary schools to promote health as a career and entry into Faculty of Medical and Health Sciences professional programmes. WAP operates within a kaupapa Māori framework across the recruitment pipeline (Year 9 to first-year tertiary study). This programme offers exposure to health career options through school presentations, Year 13 transitioning activities such as career advice and visits to Health Science facilities in University of Auckland, assistance for students to apply to the FMHS, and financial support for successful applicants.

Summary

This section presents data related to STEM tertiary qualifications as measured by TIMSS and PISA, along with discussion about Māori and Pasifika student achievement in NCEA, the national secondary school qualification. Aspects related to the provision of STEM, including teacher education and professional development, employing STEM teachers, and school links with science communities are also discussed.

The following are key points:

1. Most STEM-related Bachelors' degrees are awarded in the area of health and veterinary sciences, with numbers having steadily increased from 2006 to 2010.
2. Around 10% of STEM-related Bachelors' degrees are in natural or physical sciences.
3. The number of Bachelors' degrees in IT has declined from around 6% of all STEM-related Bachelors' degrees in 2006 to 4% in 2010.
4. For engineering qualifications, Level 1-3 certificates are most common; only around 20% of engineering qualifications are at the degree level or higher. Government funding for engineering faculties was increased by 8% for 2013, and funding has been created for an additional 1000 students at the undergraduate level.
5. Qualifications in natural and physical sciences tend to be at the degree level or higher.
6. A smaller proportion of Māori and Pasifika students complete degrees in STEM-related fields compared with their proportions in the general population. This is linked with their relative under-performance at secondary schools. Even when the numbers of students who obtained University Entrance are compared, Māori and Pasifika students are less likely to enrol in degree-level study than their Pākehā or Asian counterparts.
7. Universities offer a range of outreach programmes in schools with a primary goal of recruiting students into STEM-related qualifications at their institution. The majority of these do not appear to be linked to each other, and there is no evidence of any substantive evaluation of their effectiveness.
8. Many universities also offer programmes to specifically support Māori and Pasifika students both through the enrolment process, and during their undergraduate and postgraduate study.

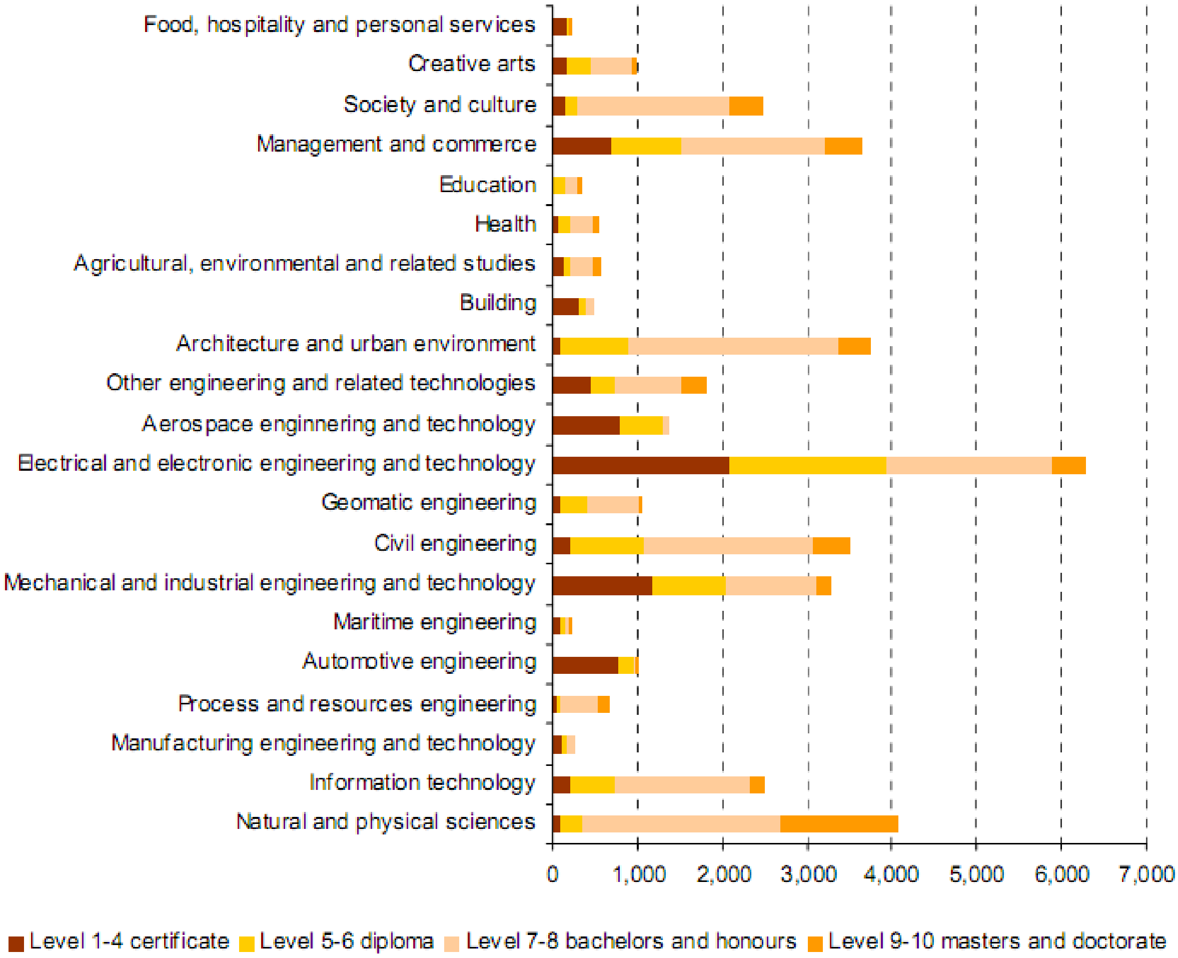
Uses of STEM beyond education

Insights from census data

According to 2006 census data, half of physical, mathematics and engineering science professionals have their highest tertiary qualification in engineering. Other common fields of study were sciences and architecture. However, there were also substantial proportions who had highest qualifications in management and commerce (9%) and society and culture (6%) (see Figure 20).

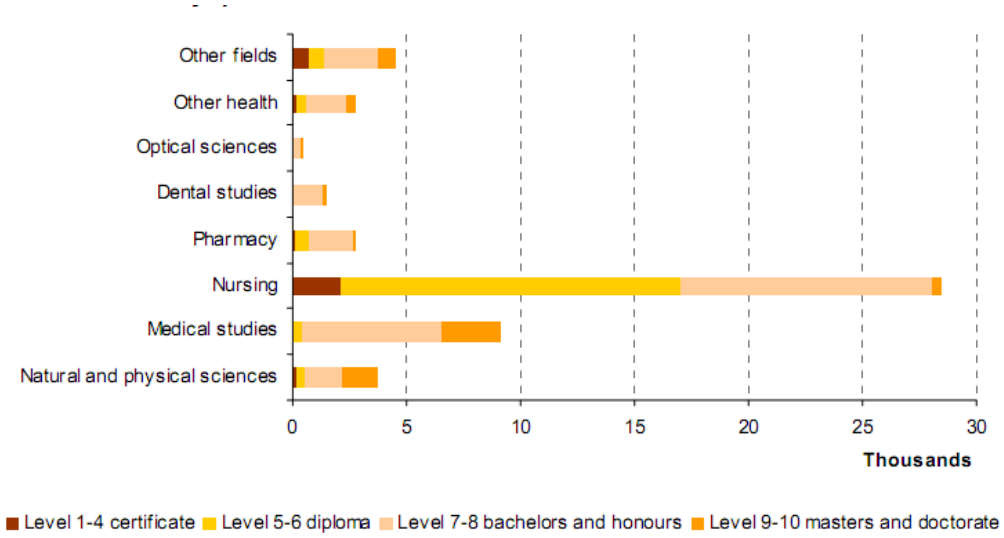
Although the New Zealand Vice-chancellors' Committee collected information annually on graduate destinations from 1996 to 2006 (NZVCC, 2008), the public information does not provide insights into the percentage of graduates employed full-time or part-time by field of study.

Figure 20: Physical, mathematical and engineering science professionals by field of study and highest level of tertiary qualification (Earle, 2008b, p. 27)



Of the life science and health professionals, the majority had their highest qualification in medical studies or nursing (see Figure 21).

Figure 21: Physical, mathematical and engineering science professionals by field of study and highest level of tertiary qualification (Earle, 2008b, p. 28)



Identifying future professional needs

The report 'Advanced trade, technical and professional qualifications' (Earle, 2008b) is part of a Ministry of Education series 'Beyond tertiary study' and highlights the increased demand for advanced skills and knowledge in the workplace, driven by:

- desires to improve innovation and productivity;
- greater use of new technologies;
- demographic changes in society and the workplace;
- construction and infrastructure development; and
- increased registration requirements for a number of occupations.

Occupations identified as having significant and persistent skill shortages included professional occupations, technicians, and trades workers.

The broad areas of study with high unmet demand for advanced qualifications were identified as being information technology, engineering,[43] building and health. For example, growth in employment from 1996-2006 was identified as being 85% for physical, mathematical and engineering science professionals, and 31% for life science and health professionals (Earle, 2008b, p. 24, drawing on census data).

Graduate shortages in these areas were seen to be compounded by a shortage of technology, science and mathematics teachers at secondary level. However, the report points out that increasing the number of people with advanced trade, technical and professional qualifications is only one part of the solution to persistent skill shortages. Other aspects include the quality and relevance of qualifications, retaining skilled workers within New Zealand, improving employment conditions (not just pay) and making best use of migration to meet immediate shortfalls (Earle, 2008b, p., 7).

Summary

There appears to be limited data related to the uses of STEM beyond secondary and tertiary education. Not surprisingly, 2006 census data suggests that the majority of physical, mathematics and engineering professionals have their highest tertiary qualification in engineering, science or architecture. However, 9% of these professionals reported a highest qualification in management and commerce, and 6% had a highest

---

[43] The report specifically identified demand in engineering for employees with diplomas and bachelors degrees, especially in electrical/electronic, civil and mechanical/industrial engineering (Earle, 2008b, p. 55).

qualification in society and culture. It is not clear, of course, how many of these also had STEM-related qualifications.

In terms of future needs and capabilities, the broad areas of IT, engineering, building and health have been recognised as needing larger numbers of qualified professionals.

Policies and strategies to enhance STEM

In New Zealand, as elsewhere, there is significant political rhetoric regarding the importance of science, technology and innovation for a growing economy. How this translates into actual policy is more difficult to identify.

At the school level, the first decade of the 21st Century saw extensive assessment reform with the introduction of NCEA. Alongside this, a revised school curriculum was released in 2007 and from 2010-2012 NCEA's achievement standards were revised and updated to reflect the revised curriculum. Schools have also been encouraged to embrace greater use of ICTs in their teaching and learning programmes, and extensive Government investment has been dedicated to this. For example, the Ministry of Education has supported ICT development in schools through

- providing enabling tools (e.g., the Laptops for Teachers scheme; the School Network Upgrade Project and most recently the rollout of Ultra-fast Broadband to schools);
- supporting teacher professional development (e.g., through the ICT-PD clusters and the Virtual Learning and Professional Development initiative);
- supporting innovation (e.g., the digital opportunities programme and e-learning teacher fellowships); and
- providing opportunities for connections between people and ideas (e.g., through the Virtual Learning Network) (Buntting, 2012).

STEM-related initiatives

The above reforms have been school-wide and across all learning areas. In relation specifically to science, technology and mathematics, a range of policies and initiatives have been referred to in the above sections of this report. It is important to note that, in New Zealand, nearly all large-scale school initiatives are Government-funded. In a few cases, initiatives are able to access philanthropic support or the private sector, but this is not common. Even fewer projects, such as the University of Auckland's Starpath Project, receive funding from the private sector that is matched dollar for dollar by Government. The initiatives that we believe are worthy of mention in the context of STEM education because of their scale include:

1. The Mathematics and Science Taskforce, which was established by the Ministry of Education in 1997 in response to New Zealand's performance in the 1995 TIMSS assessment and reported difficulties of teachers in implementing effective mathematics programmes.

   One outcome was the publication of 'Connected', a resource that aims to excite New Zealand primary school students' interest in science, technology, and mathematics and alert readers to cutting-edge scientific research. Three new titles are published each year and distributed to schools, with comprehensive teacher support materials for each book provided online.

   In a recent survey of teachers' use of science resources, 67% of primary respondents had used journals from the Connected series during the last twelve months and in the open response section Connected was the most frequently nominated best resource for integrating literacy and primary science (Hipkins & Hodgen, 2012).

Booklets from the Building Science Concepts (BSC) series[44] were also popular, and had been used in the past 12 months by 65% of the primary teachers. Teachers said BSC resources were among the best for: engaging students via practical learning activities; getting good teaching ideas; and updating their personal knowledge for teaching science.

Another project resulting from the Mathematics and Science Taskforce was the Numeracy Development Project. The focus of this project was to 'improve student performance in mathematics through improving the professional capability of teachers' (Ministry of Education, 2004, p. i). The project was first implemented in New Zealand schools in 2001. A range of evaluations are cited by Thomas and Tagg (n.d.), all indicating that the project had a positive impact on the quality of teaching and learning in mathematics. In addition, Thomas and Tagg report an average 9% improvement on a pool of items selected from the 1995 TIMSS items and administered to students in schools who had participated in the Numeracy Development Project for at least two years. The findings highlight the value of intense, prolonged professional development opportunities for teachers and schools.

2. Substantive professional development funding for the professional development of technology teachers. This was introduced initially to support teachers faced with the new technology curriculum, published in 1995. In 2004, a significant amount of funding was accessed from the Ministry of Economic Development to set up the *Growth and Innovation Framework-Technology Initiative* (GIF-Technology) (Dinning, 2007). As reported earlier, it includes

   - the development of an online resource (technology.tki.org.nz, formerly www.techlink.org.nz) that showcases examples of contemporary teaching and learning in technology and provides curriculum support for educators in their ongoing planning, implementation and review of teaching and learning programmes;
   - the Technology Beacon Practice Project, identifying and documenting case studies of exemplary classroom practice;
   - a Technology Leader Support Programme;
   - the 2007 Curriculum Support Package, providing an explanation of and guidance for the 2007 technology curriculum; and
   - the appointment of a National Technology Professional Development Manager.

   A joint learning community of teacher educators, as well as separate in-service and pre-service teacher educator learning communities has resulted in a growing level of shared understandings and a collaborative and supportive network between regions and institutions.

   While long-term funding (2004-2013) has allowed the initiative to be strategic on a level unprecedented in previous attempts to provide teacher professional development support for technology education in New Zealand, there is unfortunately no substantive evaluation of the initiative.

3. A reduction in funding for professional learning in subject-specific areas, with the funding instead being channeled into more generic programmes, including:

[44] This series is also published by the Ministry of Education and includes 64 books designed to build primary students' science concepts. The series includes science notes for the teacher, diagnostic activities, and activities to support learning.

- ICT-PD clusters and other funding for the development of teachers' ICT-related skills and pedagogies;
- Te Kotahitanga (TK).

TK is a professional development programme aimed at providing teachers with knowledge and skills for culturally responsive instruction (Bishop et al., 2007*)*. Based on the notion of fostering positive teacher-student relationships, TK posits to help mainstream teachers to reflect and challenge their own beliefs, expectations and classroom practices, especially in relation to the instruction of Māori students in their own classrooms. Teachers in the TK programme are taught to build a reciprocal relationship with their students through Māori concepts such as ako (reciprocal teaching and learning through co-construction of knowledge), manakitanga (demonstrating care) and whānau (family).

TK was first conceptualised in 2001 as collaborative narratives of the voices of students, parents, and staff in five secondary schools and later implemented as a research-based professional development programme in 2004, involving 33 secondary schools with a relatively high proportion of Māori students, and has subsequently been extended. An evaluative case study involving interviews with 150 teachers across 22 secondary schools found that teachers valued the relationship-building pedagogies (Hynds et al., 2011). For example, teachers became more aware of their own biases and assumptions about expectations for Māori students in their classrooms and worked towards overcoming 'deficit theorising' by taking an active approach to understanding their Māori students in relation to their cultural backgrounds and creating more student-focused classrooms through the conscious use of co-operative learning strategies. Not surprisingly, the implementation of a new approach to instruction was not without its challenges. For some New Zealand European teachers, repositioning their own beliefs and values can be daunting, especially when confronted with worldviews of their Māori students that are in conflict with their own. Teachers also struggled to concede authority to their students to take ownership of their own learning, while at the same time, maintaining high expectations on learning outcomes.

Evidence of the impact of TK on students' classroom experience came from an independent evaluation by an international research team (Savage et al., 2011). The researchers found that teachers in participating schools had higher levels of implementation of an 'effective teacher profile' (changes in classroom practices that affirm students as culturally located individuals) when compared with teachers from non-participating schools. Māori students who were interviewed were able to articulate that their identity as Māori learners was valued in the classrooms. They reported positive learning experiences when their teachers used culturally responsive practices.

4. LEOTC programmes

Learning Experiences Outside The Classroom (LEOTC) is a contestable contract system run by the Ministry of Education since the early 1990s. It contributes to curriculum-related programmes run by a range of community-based organisations, including zoos, museums, historic parks, art galleries, performing arts and science centres that hold significant resources and expertise used to enrich student learning within a unique Aotearoa/New Zealand context. Criteria are that LEOTC providers offer authentic hands-on, interactive learning experiences for students, and that providers and schools work in partnership to ensure that programmes meet the learning needs of students and support effective teaching and learning.

Deaker (2006), in a policy review paper for the Ministry of Education, points out the alignment between the goals of LEOTC and other Ministry of Education documentation, including:

- The Ministry of Education's Statement of Intent, 2006-2011, which emphasises effective teaching for all students, family and community engagement in education, and developing quality providers
- The Schooling Strategy, 2005-2010, which requires all schools to work towards 'effective teaching'
- The revised New Zealand Curriculum, which underlines the importance of stronger connections between schools and the wider community.

However, Deaker (2006) also points out the desire by LEOTC providers for the inclusion of teacher professional development into the requirements, and longer funding terms for substantial and proven providers.

5. The biotechnology and science learning hubs (www.biotechlearn.org.nz and www.sciencelearn.org.nz)

   These web-based resources, funded by the Ministry of Business, Innovation and Employment, were launched in 2005 and 2007 respectively. They offer extensive content in the form of multimedia representations of contemporary New Zealand research and researchers. They have received considerable national and international attention because of their capacity to give schools access to the science/technology communities in a manner that is considered to be sustainable by both the education and research sectors.

6. The Assessment Resource Banks (ARBs)

   The ARBS are large collections of Science, Mathematics and English assessment resources for Years 3-10 (7-14 year olds) that have been designed to be used or modified by teachers for formative and summative purposes. Extensive teacher notes include background knowledge, examples of student responses, diagnostic information, and suggestions for next learning steps.

7. Teacher fellowships

   The teacher fellowship scheme is funded by the Ministry of Business, Innovation and Employment and administered by the Royal Society of New Zealand. It offers primary, intermediate and secondary teachers the opportunity to improve their teaching through working in New Zealand-based host organisations for two terms (changed in the late 2000s from one term to year-long placements). They are currently offered in two forms:

- Primary science teacher fellowships, designed to create curriculum leaders in science for the primary sector. This initiative also requires an agreement from the school to make science a priority learning area for the year following the fellowship.
- Endeavour teacher fellowships, open to all fully registered teachers who have taught in the science, mathematics or technology for five or more years.

Policy disconnects

Despite extensive rhetoric around the importance of science, technology and innovation to national economic and social well-being, there appears to be a lack of cohesion and coherence across many of the policy initiatives. For example, while Government funding has recently increased for STEM areas at tertiary level, there appears to have been less consideration of supply and demand. In other words, although the cost categories may have increased, there does not appear to be related policy regarding recruitment into tertiary STEM, or subsequent career opportunities and retention of STEM professionals in New Zealand.

At the school level, professional development funding is currently being channelled into numeracy and literacy, or more general professional development related to culturally responsive pedagogies and the use of ICTs to support teaching and learning. While there has been some funding for secondary school STEM teachers as a result of the revised curriculum and alignment of national standards, many teachers would say that this has not been nearly sufficient. Professional associations provide an important alternative avenue for teacher professional development through local meetings and national conferences. They are largely self-funding.

At the primary level, teacher confidence and competence teaching STEM-related areas is of concern, and support for teaching science and technology is under-valued in many schools. At the secondary level, opportunities for developing flexible and engaging STEM programmes possible within the current curriculum and assessment framework have largely not been realised. This appears to be related to teacher understanding of NCEA, traditional schooling structures and timetabling, University entrance criteria, and societal expectations about what school subjects should look like. Opportunities to embed aspects associated with 'innovation education' – fostering the skills and attributes important for innovation – within the latest curriculum and assessment reforms have largely been missed (Jones & Buntting, 2013).

Summary

The vast majority of education initiatives in New Zealand are Government funded, and unfortunately many of these remain under-evaluated. For example, there is little evidence of the actual impacts of the ten-year GIF-Technology funding for technology teachers' professional development. The Science and Biotechnology Learning Hubs have similarly not been extensively evaluated. Of course, many of the iniatives take time to develop and evaluation that is premature is not likely to be helpful. However, opportunities to learn from the implementation of the iniatives and inform their future development are lost. Other initiatives, such as Te Kotahitanga, have been evaluated, although the impact of culturally responsive pedagogies on STEM learning remains unknown.

In addition, mixed messages around STEM education pervade the school and policy system, with a lack of cohesion and coherence between policy initiatives. While the Government espouses the need for a 'knowledge economy', it has not gone far enough in supporting curriculum and school changes, including changes in teacher education and teacher professional learning.

Concluding thoughts

New Zealand's future lies in its ethnic diversity. Of particular relevance to this report is the increasing proportion of Māori and Pasifika peoples who will be entering the workforce, and the challenge that this poses for education in general, including STEM education. In particular, participation, access and achievement of these ethnic groups needs to continue to be addressed. This is not a simple issue – education cannot be considered in isolation from other socio-economic and health disparities.

In recent years there has also been a major shift in the Māori economic profile, with the Māori economy currently representing NZ$ 40 billion. Māori are increasingly active in addressing their own educational and community issues, including those related to economic, environmental and sustainable practices, and increasing calls from iwi leaders for Māori to participate in and drive their own scientific and technological development. As a result, there is currently increasing community support for greater participation and achievement in STEM education. There is also increased national discussion around the interface between science and indigenous knowledge, and this offers an opportunity for New Zealand's STEM education to offer a distinctive flavour. This area is evolving, as it is only recently that Māori have gained greater influence in their own economic decision making.

The Government is also calling for greater STEM participation across all ethnic groups, but there appears to be little policy cohesion. For example, while funding for science and engineering has been slightly increased at the tertiary level, there has been less consideration of what happens feeding into the tertiary sector, and retaining STEM graduates in New Zealand.

At the school level, science and technology are largely undervalued at the primary level. This has been exacerbated by the curriculum's emphasis on five key competencies – 'capabilities for living and lifelong learning' (Ministry of Education, 2007b, p. 12) – and the introduction of numeracy and literacy national standards. Both these strategies have tended to reduce the time and resources spent on primary science and technology, including teacher professional development. The general under-valuing of science within the primary science curriculum has been investigated by the Education Review Office (2010b, 2012).

In international comparisons, New Zealand's primary students are only on par with or below the TIMSS scale average in both science and mathematics, and performance in science is decreasing – although increasing in mathematics. As with all other national and international comparisons, Māori and Pasifika are over-represented in lower achievement bands. Primary level achievement and attitude is critical because of the flow-on into high school subject pathways. While there is increasing rhetoric of the importance of engaging young students in science and technology, there is little evidence of real change. Instead, there is reduced time spent on science and technology, and reduced teacher professional development. On the other hand, resources such as the *Connected* series (initiated as a result of the Mathematics and Science Taskforce in 1997), LEOTC opportunities, and the Science and Biotechnology Learning Hubs continue to be valued by teachers.

At secondary level, reporting on numeracy and literacy national standards are mandated for Years 9 and 10 from 2014 and the impacts of this are yet to be understood. In contrast to our TIMSS performance was better at Grade 8 level (administered in the first year of secondary school) than at Grade 4, and our PISA placing was very high (only two countries out of 57 had a statistically higher ranking than NZ in scientific literacy in 2006). However, New Zealand has a relatively large proportion of students with very low levels of scientific literacy when compared with other top-performing jurisdictions. In contrast to primary schools, there is a greater emphasis on subject-specific professional development, although this is likely aligned with recent changes to both the curriculum and the national examination system at senior secondary level.

Changes to both the curriculum and the assessment system opened up opportunities for the development of innovative classroom programmes – including programmes of greater relevance to different student groups – although in practice these have not been realised. This is likely related to the ongoing influence of conservative University entrance requirements, and traditional school practices. As with other national and international testing, Māori and Pasifika students are less likely to gain NCEA Levels 1, 2, and 3.

In line with national education policy, several initiatives specifically target Māori and Pasifika students. Te Kotahitanga and He Kakano are two of the largest teacher and principal professional development programmes, although these focus on generic culturally responsive pedagogies and leadership programmes. The real impact on student engagement and achievement in STEM-related subjects is yet to be understood. Several school-community links also specifically target Māori and/or Pasifika students, and many of these are iwi-driven.

New Zealand is perhaps unique in that nearly all professional development funding is directly targeted and prioritised by Government. There is virtually no funding that is either un-tagged, or from non-Government sources. This represents a tension with the 'Tomorrow's Schools' reforms, which gave schools through their Boards of Trustees, far greater decision-making power regarding the implementation and assessment of classroom programmes. The small proportion of un-tagged funding provided to each school as part of their bulk operational grant is generally not spent on STEM-related professional development.

There also appears to be very little cohesion between various Government policies and initiatives related to STEM education. In a small country, there would seem to be scope for greater efficiencies and better targeting across the system. Instead, an atomistic approach seems to have dominated. There may be an opportunity to change this with the release of the 2011 report on the state of science education by the Prime Minister's Chief Science Advisor.

In developing this report, several gaps in existing data have arisen:

1. We know very little about the impact of culturally relevant pedagogies on students' engagement and achievement in STEM-related subjects.
2. While there is a focus in national data collection on the grouping of students into Pakeha, Māori, Pasifika and Asian, there is less emphasis on differences between those with English as a first language, and those with English as an additional language. (According to TIMSS data, New Zealand has one of the highest proportions of students who speak a language different to the test language – i.e., English – at home.)
3. New Zealand's large number of small and rural schools poses challenges in terms of offering students curricula choices. While these schools are generally well equipped and resourced in terms of ICT capability, the impact of IT-mediated teaching and learning in STEM-related subjects is not understood. In addition, these schools are more likely to struggle to employ effective staff in STEM-related areas.

Although significant issues have been highlighted in relation to STEM education in schools, there appears to be no obvious decline in absolute and relative terms in undergraduate and postgraduate qualifications in STEM.

New Zealand is a small country with a long history of a national curriculum. Our unique colonizing history means that there is Government prioritization of education of Māori as Māori. In addition, both iwi and Government are recognizing the importance of STEM professionals and enhanced general scientific and technological literacy for economic and social development. Within this broader context, an opportunity exists for greater policy cohesion and coherence. However, there are lessons to be learned about creating a more integrated approach to enhancing STEM engagement and achievement for all groups at all levels of education, from early childhood through to tertiary. If real, long-term gains are to be made, a system-wide approach will be required to enhance the supply and demand cycle and align economic and education drivers.

References

ACNielson. (2010). *Science and the general public*. Report prepared for the Ministry of Research, Science and Technology. Wellington, NZ: Author.

Bishop, R., Berryman, M., Cavanagh, T., & Teddy, L. (2007). *Te Kötahitanga Phase 3 Whänaungatanga: Establishing a culturally responsive pedagogy of relations in mainstream secondary school classrooms*. Report to the Ministry of Education. Wellington: Ministry of Education.

Buckley, J. (2009). *Cross-national response styles in international educational assessments: Evidence from PISA 2006*. https://edsurveys.rti.org/PISA/documents/Buckley_PISAresponsestyle.pdf

Bull, A. with Bolstad, R., & Spiller, L. (2012). *Science community engagement with schools. Scoping the field*. Report prepared for the Ministry of Education. Wellington, NZ: NZCER.

Buntting, C., with MacIntyre, B., Falloon, G., Cosslett, G., & Forrett, M. (2012). *Science in the New Zealand Curriculum: e-in-science. Milestone 3: Developing innovation for e-learning in science*.

Buntting, C., & Jones, A. (2012). Expanding the capacity for connection: The New Zealand biotechnology learning hub. In B. France & V. Compton (Eds.), *Bringing communities together: Connecting learners with scientists or technologists* (pp. 101-112). Rotterdam, The Netherlands: Sense.

Bybee, R., & McCrae, B. (2011). Scientific literacy and student attitudes: Perspectives from PISA 2006 science. *International Journal of Science Education, 33*(1), 7-26.

Carr, M. (2001). *Assessment in early childhood settings: Learning stories*. London: Sage.

Caygill, R., & Kirkman, S. (2008). *Trends in Year 5 mathematics achievement 1994-2006. New Zealand results from three cycles of the Trends in International Mathematics and Science Studies.* Wellington, NZ: Ministry of Education.

Chamberlain, M. (2007). *Mathematics and science achievement in New Zealand: Summing up New Zealand's participation in three cycles of TIMSS at Year 9*. Wellington, NZ: Ministry of Education.

Chamberlain, M., & Caygill, R. (2012). *Key findings from New Zealand's participation in the Progress in International Reading Literacy Study (PIRLS) and Trends in International Mathematics and Science Study (TIMSS) in 2010/2011*. Wellington, NZ: Ministry of Education.

Deaker, M. (2006). *The provision of LEOTC to New Zealand schools: A policy review paper for the Ministry of Education*. Retrieved from http://eotc.tki.org.nz/LEOTC-home/Research-and-presentations/Ministry-research

Dinning, N. (2007). Enabling technological literacy in New Zealand: The GIF-Technology Education initiative. *Proceedings of the pupils' attitudes towards technology (PATT) 18 conference: Teaching and learning technological literacy in the classroom* (pp. 273-281). Glasgow, Scotland: University of Glasgow.

Durie, M. (2001, February). *A framework for considering Māori educational achievement*. Opening address to the Hui Taumata Matauranga Tuarua. (24 February 2001) Retrieved June 24, 2004, from http://www.lianza.org.nz/text_files/Māori1.doc

Earle, D. (2007). *Te whai i ngā taumata atakura: Supporting Māori achievement in bachelors degrees*. Wellington, New Zealand: Ministry of Education.

Earle, D. (2008a). *Hei titiro anō i te whāinga: Māori achievement in bachelors degrees revisited*. Wellington, New Zealand: Ministry of Education.

Earle, D. (2008b). *Advanced trade, technical and professional qualifications. Identifying demand.* Wellington, NZ: Ministry of Education.

Education Review Office. (2010a). *Promoting success for Māori students: Schools' progress*. Wellington, New Zealand: Author.

Education Review Office. (2010b). *Science in Years 5 to 8: Capable and competent teaching*. Wellington, NZ: Author.

Education Review Office. (2012). *Science in the New Zealand Curriculum: Years 5 to 8*. Wellington, NZ: Author.

Engler, R. (2010). *Are particular school subjects associated with better performance at university?* Wellington, NZ: Ministry of Education.

Gluckman, P. (2011). *Looking ahead: Science education for the twenty-first century. A report from the Prime Minister's Chief Science Advisor*. Auckland, NZ: Office of the Prime Minister's Science Advisory Committee.

Joyce, C., & Darr, C. (2008, July). *The role of an online repository of assessment tasks and resources: the place of the Assessment Resource Banks*. Paper presented at the 6th conference of the International test Commission: The impact of testing on people and society: Enhancing the value of test use. Liverpool. http://www.nzcer.org.nz/pdfs/16705.pdf

Hipkins, R., & Hodgen, E. (2012). *Curriculum support in science. Patterns in teachers' use of resources.* Report prepared for Ministry of Education.

Hipkins, R., & Bolstad, R. (2005). *Staying in Science*. Wellington, New Zealand: New Zealand Council for Educational Research.

Hipkins, R., Roberts, J., Bolstad, R., & Ferral, H. (2006). *Staying in science 2: Transition to tertiary study from the perspectives of New Zealand Year 13 science students*. Wellington, New Zealand: New Zealand Council for Educational Research.

Hume, A., & Coll, R. (2010). Authentic student inquiry: The mismatch between the intended curriculum and the student-experienced curriculum. *Research in Science & Technological Education, 28*(1), 43-62.

Hynds, A., Sleeter, C., Hindle, R., Savage, C., Penetitio, W., & Meyer, L. H. (2011). Te kota-hitanga: A case study of a repositioning approach to teacher professional development for culturally responsive pedagogies. *Asia-Pacific Journal of Teacher Education, 39*, 339-351.

Irving, S.E., & Gan, M. (2012). Data systems in secondary schools: The state of play. *Computers in New Zealand Schools, 42*(2). http://education2x.otago.ac.nz/cinzs/mod/resource/view.php?id=313

Jones, A. (2012). Risks in narrow focus. *Waikato Times, 24 May 2012*. http://www.stuff.co.nz/waikato-times/opinion/columnists/6976563/Risks-in-narrow-focus

Jones, A., & Buntting, C. (2013). The role and place of science and technology education in developing innovation education. In L.V. Shavinina (Ed.), *Handbook on Innovation Education* (pp. 419-429). New York: Routledge.

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, The Netherlands: Sense.

Jones, A, & Cowie, B. (2010). The history and influences on curriculum development in New Zealand. In J.D. Kirylo & A. Nauman (Eds.), *Curriculum development: Perspectives from around the world* (pp. 237-248). Washington, DC: Association for Childhood Education International.

Kukutai, T. (2011). Contemporary issues in Māori demography. In McIntosh, T. & Mulholland, M. (Eds.), *Māori and social issues* (Vol. 1). Wellington, New Zealand: Huia.

Lee, M. (2012). *Monitoring teacher supply. Survey of staffing in New Zealand schools at the beginning of the 2012 school year*. Wellington, New Zealand: Ministry of Education.

Loader, M., & Dalgety, J. (2008). *Students' transition between school and tertiary education. 2nd edition*. Wellington, New Zealand: Ministry of Education.

Madjar, I., McKinley, E., Jensen, S., & Van Der Merwe, A. (2009). *Towards university: Navigating NCEA course choices in low-mid decile schools*. Starpath Project, The University of Auckland. http://www.education.auckland.ac.nz/uoa/home/about/research/starpath-home/starpath-research

May, H. (1997). *The discovery of early childhood.* Auckland: Auckland University Press/Bridget Williams Books with the New Zealand Council for Educational Research.

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.
McKinley, E., Madjar, I., van der Merwe, A., Smith, S., Sutherland, S., & Yuan, J. (2009). *Targets and talk: Evaluation of an evidence-based academic counselling programme*. Starpath Project, The University of Auckland. http://www.education.auckland.ac.nz/uoa/home/about/research/starpath-home/starpath-research
Meyer, L., McLure, J., Walkey, F., McKenzie, L., & Weir, K. (2006). *The impact of NCEA on student motivation. Final report to the Ministry of Education*. Wellington, NZ: Victoria University of Wellington.
Ministry of Education. (n.d.). *Mathematics achievement: Primary schooling*. Wellington, NZ: Author.
Ministry of Education. (1996). *Te Whariki*. Wellington, NZ: Learning Media.
Ministry of Education. (2007). *The New Zealand Curriculum*. Wellington, NZ: Learning Media.
Ministry of Education. (2010). *Ngā Haeata Mātauranga 2008/09*. *Annual report on Māori education*. Wellington, NZ: Author.
Moeed, A. (2010). *Science investigation in New Zealand secondary schools: Exploring the links between learning, motivation and internal assessment in Year 11*. Unpublished doctoral dissertation. Victoria University of Wellington.
Mullis, I.V.S., Martin, M.O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in Mathematics*. Boston, MA: TIMSS & PIRLS International Study Centre.
Mullis, I.V.S., Martin, M.O., Foy, P., & Stanco, G.M. (2012). *TIMSS 2011 international results in Science*. Boston, MA: TIMSS & PIRLS International Study Centre.
NZVCC. (2008). *NZUniGradStats*. Wellington, NZ: Author.
Royal Commission on Social Policy. (1987). *A fair and just society*. Wellington, NZ: Author. Savage, C., Hindle, R., Meyer, L. H., Hynds, A., Penetito, W., & Sleeter, C. (2011). Culturally responsive pedagogies in the classroom: Indigenous student experiences across the curriculum. *Asia-Pacific Journal of Teacher Education, 39*, 183–198.
Satherley, P. (2006). *Student outcome overview 2001-2005*. Wellington, New Zealand: Ministry of Education.
Scott, D. (2008). *How does achievement at school affect achievement in tertiary education?* Wellington, New Zealand: Ministry of Education.
Stewart, G.M. (2012). Achievements, orthodoxies and science in Kaupapa Māori schooling. *New Zealand Journal of Educational Studies*, *47*(2), 51-63.
Thomas, G., & Tagg, A. (n.d). The impact of the numeracy development project on mathematics achievement. Retrieved from http://www2.nzmaths.co.nz/numeracy/References/comp_thomas_tagg2.pdf
Ussher, S. (2007). *Tertiary education choices of school leavers*. Wellington, New Zealand: Ministry of Education.