combination of new initiatives and some changes of emphasis within current activities to build on these initiatives and continue progress.

This plan will focus on three Strategic Action Areas:

- ***Strategic Action Area one**:* education sector
- ***Strategic Action Area two**:* public engagement with science and technology
- ***Strategic Action Area three***: science sector engaging with the public.

The three Strategic Action Areas are interconnected. The advice of the Science in Society Reference Group is that any action in the education sector must be complemented by support from the wider school community. Enhancing public engagement with science and technology cannot be separated from encouraging scientists to engage effectively with the public. This plan addresses the barriers and enablers to creating a more 'publically engaged' science sector together with a more 'scientifically engaged' public.

This plan acknowledges and recognises the importance of mātauranga Māori (traditional knowledge) to build cultural confidence and identity, and how, through this, New Zealand can grow its skills and generate innovation and creativity. Each of the three Strategic Action Areas will be developed in ways that respect whānau, hapū and iwi as the key conduits of mātauranga Māori, and focus on building Māori capability in science and technology to support their management of their natural resources and overall development.

This plan sets out actions under each of the Strategic Action Areas over the next three years. As this is New Zealand's first Science in Society strategic plan in 2015 the Science in Society Reference Group will assess progress on the plan and advise government on any modifications needed to the actions to better deliver on the outcomes.

The plan recognises the importance of maths skills as part of the overall package of STEM skills. It does not specifically address increasing the supply of students with maths competencies as this is being addressed by the literacy and numeracy taskforce.

PART 1 Background

The National Science Challenges and the Leadership Challenge

Following significant public engagement in early 2013, the National Science Challenges Panel recommended a set of national science challenges to address our most pressing health and environmental issues, and to advance our economy through innovation. The Panel also recommended a 'Science in Society leadership challenge' that they saw as "the most important challenge to address" if New Zealand is to advance through the responsible application of science and innovation and benefit optimally from its investment in scientific research. The Panel considered the 'Science in Society leadership challenge' to be central to the success of the National Science Challenges.

The 'Science in Society leadership challenge' asked government to take a lead in facilitating better engagement with science in New Zealand in four distinct but interrelated areas:

1. Science, technology, engineering and maths (STEM) education in primary and secondary schools.

2. 'Public understanding of science', including both the potential and the limits of scientific knowledge and managing uncertainties. Here, 'public' is understood in a pluralistic sense and necessarily includes the elected representatives and civil servants that work in the interest of the New Zealand public.

3. Early engagement by citizens and other knowledge users on the implications of new technologies and novel applications of existing technology, and to help ensure the public relevance of New Zealand's science and research agenda.

4. National capacities in technology assessment, risk forecasting and using this in developing societal consensus in using and limiting technologies.

In May 2013, the Government formally accepted the 'Science in Society leadership challenge, with the Minister of Science and Innovation and the Minister of Education subsequently announcing development of this strategic plan in November 2013. In order to manage the scope of the plan the technology assessment and risk forecasting area is not addressed in the plan at this stage. Annex 1 sets out the process used for developing this plan.

Methodology for developing this plan

This is the first Government strategic plan for Science in Society.

The plan sets out the objectives and outcomes the Government wishes to achieve for Science in Society over the longer term. It sets out the available evidence on where New Zealand is at now and identifies the challenges that need to be addressed. It sets out the Government's progress so far in addressing these challenges. It concludes by identifying the tasks that remain and by setting out a three-year plan of action to make further progress towards the objectives and outcomes.

PART 2 Making the Case

2.1 Why Science in Society matters

21st century life is driving the need to increase our engagement with science and technology

Many of today's toughest decisions at local, national and international levels – about public health; natural resources stewardship or new and emerging technologies for instance – require all of us to weigh both scientific evidence and social values. The National Science Challenges are science priorities that respond to the most important, national scale issues and opportunities identified by science stakeholders including the New Zealand public. Many of these and other challenges we face today and into the future will require creative and innovative solutions that have a basis in scientific discovery and technological application[3]. New Zealanders must be encouraged and equipped to engage in the key questions facing our society now and in the future.

Science, technology, engineering and maths (STEM) skills are increasingly important both globally and for all New Zealanders. The pace of technological change, the ability to engage with modern society and nature of employment in the future means that these skills will be important for everybody[4].

The goal of an 'innovation-led' economy is driving the need for an increasingly STEM competent workforce

New Zealand's economic and social wellbeing depends in large part on the productivity and competitiveness of the economy. Innovation that leads to increased productivity and wellbeing is increasingly being seen around the world as an important way to generate economic growth and improved living standards[5].

The Government is committed to materially lifting New Zealand's long-run productivity growth while maintaining our high rate of labour force participation[6]. To do this, New Zealand needs a high performing and responsive innovation system and skilled people who can problem-solve and create and deliver high-value products and services, cultivate new markets and sell to the world. We also need businesses, policy makers and citizens that are ready to absorb and apply new ideas and approaches.

Our science system – particularly the tertiary education organisations that undertake research-led teaching – has a vital role in educating a future generation of scientists with the advanced science skills that are needed in leading-edge businesses. New Zealand has to be seen internationally as an 'innovation destination'. We must be able to attract and retain the right talent at the right time to contribute to our vital science. Attracting overseas investment in our research is also important for our economic growth.

A creative and innovative culture and a wide range of skills are needed for innovation, societal advancement and sound environmental stewardship. Internationally STEM skills underpin the development of new technologies, the application of existing technologies and the development of new, high-value products[7]. STEM skills and competencies also underlie growth in many industries, such as IT-related industries[8] and are highly transferable across industries[9].

STEM skills, like other kinds of skills, are acquired by individuals over time and in a wide range of ways. They need to be developed as part of the key competencies for life-long learning[10]. An individual with higher levels of competency has a much lower likelihood of experiencing both economic and social disadvantage than an individual with lower competency levels[11].

Students' career choices are influenced beyond school by family, whānau, iwi and the wider community, with parents providing the most important influences[12]. Greater community engagement with science and technology could increase the value students and their family or whānau place on the opportunities STEM subjects offer as career pathways.

The Ministry of Education is focused on ensuring that the education system delivers on the Government's key goals of improved outcomes for all New Zealanders, and stronger economic growth for New Zealand. It is the lead agency on boosting skills and employment. Our ultimate goal is to equip young people with the skills to live a fulfilling life and contribute to New Zealand's economic prosperity.

2.2 Scope of the plan

The plan focuses on supporting and equipping New Zealanders to engage in the key questions facing society and the supply of STE skilled people through the primary, secondary and tertiary education system. The plan does not cover the supply of maths skills and demand for STEM skills as these issues are being addressed through the Business Growth Agenda and the literacy and numeracy taskforce. It also does not address adult maths literacy as the Government is addressing these issues through the Tertiary Education Strategy and the Tertiary Education Commission's Adult Literacy and Numeracy Implementation Strategy.

2.3 Objectives of the plan

The principal objective of this strategic plan is to:

> Encourage and enable better engagement with science and technology across all sectors of New Zealand.

This means:

- a more scientifically and technologically engaged public and a more publicly engaged science sector
- more science and technology competent learners choosing STEM-related career pathways.

Outcome 1: A more scientifically and technologically engaged public and a more publicly engaged science sector

We will know we're making progress on this when:

- a greater proportion of New Zealanders are engaged with science and technology
- there is more in-depth media reporting on science and technology based on robust scientific evidence
- there are increased opportunities for the public to learn and be involved in scientific research and uptake continues to grow across all tiers of society
- there are more opportunities for the public to engage in discussion about societal use and limits of new technology and applications for existing technology
- publicly funded research reflects topics of importance to New Zealanders recognising the diverse needs and issues of communities.

Outcome 2: more science and technology competent learners choosing STEM-related career pathways

We will know we're making progress on this when:

- we achieve greater student demand for STEM courses and qualifications at all levels of the qualifications framework (1-10)
- we have developed greater teacher confidence in teaching for STM outcomes
- teachers have improved access to the resources they need to teach STM subjects and links between the STM curriculum and career pathways are clarified.

Outcome 3: a more skilled workforce and more responsive science and technology

In the longer term, we expect that progress towards outcomes one and two will contribute to New Zealand's economic growth and social and environmental wellbeing through:

- a greater number of New Zealanders with the skills needed to support creativity, innovation and knowledge uptake and use.
- publicly funded science and technology which responds to the needs of New Zealanders and New Zealanders make more informed decisions on issues of importance to 21st century life.

2.4 The State of Play – what we know and what we don't know

How scientifically and technologically engaged are the public and how publicly engaged is the science sector?

There is no current comprehensive measure of public engagement in science or technology or adult STEM literacy

It is difficult to measure public engagement in science and technology and there is no internationally accepted metric to capture it. The best New Zealand evidence is a survey of public attitudes to science in New Zealand[13]. The survey identified that about half of New Zealanders were actively interested in science and the other half did not recognise the relevance of science in their daily lives[14] (44%) or were disengaged in science (9%). Similar surveys have been done in other countries. However it is difficult to draw comparisons given differences in the questions[15]. The Government has not surveyed public attitudes to technology outside this survey.

Relative to comparable countries, a relatively high proportion of New Zealand adults have a secondary or tertiary qualification[16]. There is no data on the proportion of these qualifications that are in STEM subjects. From 2016 New Zealand will assess adult competencies in reading, mathematics and problem solving in technology-rich environments through the Programme for the International Assessment of Adult Competencies.

There is limited data on the level and effectiveness of the engagement of the science sector with the public

In 2013/14 the Government will invest $1.36b[17] to support science and innovation in New Zealand. A proportion of that expenditure is expected to be spent on by universities and science organisations on making research more accessible to end-users through communication, public outreach and public education, but it is difficult to estimate the proportion. Other government investment in these organisations may also be spent on communication, public engagement and education.

There are also many local government and private sector organisations, such as industry training providers, zoos, museums, charities and businesses that engage with the public on science and technology for education, cultural and marketing reasons. The Government also invests $167m in public broadcasting services and funding museums[18].

It is inherently difficult to evaluate the impact of public engagement activities[19].

Since the Science Media Centre was established in 2008, 'science' in the media has increased by 75%[20].

How competent are STEM learners and how many are choosing STEM-related career pathways?

There are STEM skills shortages

There are currently skills shortages for many kinds of scientists, engineers, technologists, health and ICT professionals[21]. Demand for workers in many STEM-related occupations is expected to grow due to a variety of factors[22]. In addition, many jobs not directly STEM-related require STEM competencies. Internationally it is estimated that up to 75% of high-growth jobs require STEM skills and competencies[23].

The number of NZ graduates is growing, but international demand is growing faster

The number of domestic students completing bachelor degrees across all fields of study has increased from 19,596 in 2005 to 25,350 in 2012. In the natural and physical sciences the increase has been from 1,937 in 2005 to 2,649 in 2012. The numbers of degree-level engineering training places funded by the government has recently increased. The industry training providers are facing difficulties in growing engineering at technician and technology qualification levels[24].

There is a global demand for those with STEM qualifications. Those who gain STEM qualifications required for job-shortage areas can be lost from New Zealand to the global job market or other careers. Many New Zealand graduates with the skills matched to the New Zealand market go overseas to work. Much of this skills loss is replaced by highly skilled immigrants. However, it is expected to become increasingly difficult to attract these immigrants as wages rise in increasingly knowledge-intensive Asian economies.

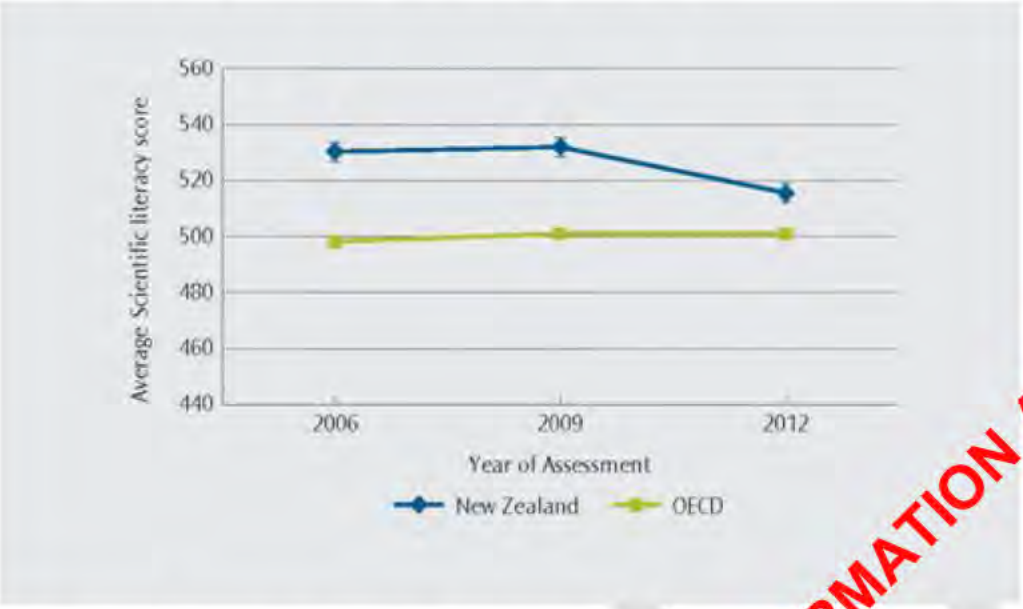
New Zealand school student performance in science has declined

New Zealand has a highly respected education system. The World Economic Forum's Global Competitiveness Index for 2013[25] noted that New Zealanders spend the longest time in education from primary to tertiary, at 19.67 years and ranked New Zealand seventh for overall education indicators out of 142 countries.

Despite this, there is a gradual decline in the proportion of students enrolled in science-related subjects in years 11 to 13[26].

New Zealand students' performance in science has also declined, and the decline is more marked in the later years of schooling. The average performance of New Zealand year 5 students for science in 2010/11 was significantly lower than in 2002/3[27] and there has been no significant change in performance for year 9 students since 1994/5. The performance of New Zealand students at age 15 years (most students are in year 10 at this age) in science remained relatively stable up to 2009 and declined between 2009 and 2012[28].

Figure One: Graph showing changes in the average science literacy score for New Zealand students at 15 years between 2006 and 2012 compared to the OECD average[29]



The National Monitoring Study of Student Achievement (NMSSA) and the Programme for International Student Assessment (PISA) results also show growing inequity in student performance in science, particularly for Māori students and Pasifika students.

There is limited data on school student performance in technology

There is limited data on student performance in technology because it is not measured by PISA or TIMMS, and NMSSA is yet to assess it.

What is causing the student performance decline?

Research suggests that student achievement in science is declining because science teachers are not confident in their ability to teach science, particularly to diverse groups. Teachers do not have access to appropriate resources, and students lack confidence in their ability to succeed in STE subjects and lack support for deciding on senior secondary school subjects[30].

2.5 The challenges and how we can best address them

The challenges are:

- Increasing the engagement of New Zealanders, across all sectors, with science and technology and increasing the effectiveness of the science sector's engagement with the public
- Increasing the numbers of learners with STE competencies to meet the needs of their everyday lives and the 21st century labour market.

To address these challenges we need to:

- *Build a nationally supportive environment for public engagement in science and technology and, equally, for the science sector's engagement with the public.*

  This needs to focus on identifying, encouraging and supporting the most effective ways for the science sector and other science and technology communicators (such as the media, museums and event organisers) to engage with the public, particularly the proportion of New Zealanders that are disengaged or do not see the relevance of science in their daily lives. The environment needs to encourage two-way dialogue between practitioners of science and technology and the New Zealand public. There is already significant activity in these areas so encouraging good practice and greater coordination could have benefits.

- Improve teacher confidence through high quality science and technology teacher education, support quality teaching, learning and assessment in science and technology;
- Develop science and technology-specific curriculum materials and support teachers to use them;
- Improve the visibility and coherence of STEM career pathways which are well-matched to the needs of an evolving labour market; and
- Improve linkages between STM educators, scientists, technologists and learners and the community

  These are the key levers that national and international research on effective teaching and learning in science and technology[31] have identified as critical for improving student engagement and achievement. A comprehensive and coherent programme of improvement that drives these levers and utilises all of the existing resources and expertise across the science and technology education systems is needed to meet the challenge of increasing the STEM competencies of New Zealand's young people.

2.6 What we're already doing

New Zealand has already put in place several policies and initiatives to help address these challenges.

Initiatives that promote better engagement between science and technology and the public

Expectations on publicly funded researchers to make research public

A number of current policies for research are designed to promote public access to the knowledge produced by New Zealand's publicly funded researchers. For example, the Government expects researchers receiving public funds, such as through contestable science and research funding, the Marsden Fund and Health Research Council, to make research public and provide public engagement and outreach.

The Crown Research Institute's (CRIs) Statement of Core Purpose includes high level statements on engagement with key stakeholders including government, industry and Māori and to transfer technology and knowledge to key stakeholders.

Expectation of public engagement in National Science Challenges

The participatory approach that was used to develop the National Science Challenges has increased the public understanding of how science contributes to the nation's wellbeing and encouraged a more scientific approach to the challenges facing us. Also, the request for proposals for the first ten National Science Challenges further sets expectations for engagement by the science sector with the public by requiring submitters to outline the following:

- how they will involve the public in their proposed research;
- how they intend to engage the public with their proposed research; and
- the outreach, communication, and education activities they are looking at implementing.

Raising the profile of science and technology and improving reporting of science by the media

MBIE also funds initiatives that encourage the science sectors engagement with the public in science through the 'Engaging New Zealanders with Science and Technology' appropriation[32]:

- The Prime Minister's Science Prizes and the Rutherford Medal – prizes for scientific research or technological practice that raise the profile and prestige of science.
- The Science Media Centre – a centre that translates science and technology issues for the media and educates scientists on engaging with the media to improve the quality and professionalism of science and technology reporting.
- Science/Biotechnology Learning Hubs (provides an online repository of New Zealand science for use by teachers and other New Zealanders) and Science, Maths and Technology Teacher Fellowships (six month fellowships for primary and secondary teachers). Both provide science teachers with tools to enhance the teaching of STEM.

STEM Education initiatives

The New Zealand Curriculum (NZC) and Te Marautanga o Aotearoa address STM skills development and building a scientifically and technologically engaged population more generally. The NZC identifies five key competencies which are to be developed through the opportunities afforded students in the eight learning areas of the curriculum.

Science literacy is valued as an outcome at the heart of the science learning part of the NZC. It is supported by students developing the key competencies as well as by other resources in other education and community contexts.

Strategic leadership and coordination

This aims to build school and science-community partnerships that support school students' science learning through the identification and development of sustainable links between schools and the science community to make the most of New Zealand's collective strengths and resources.

The Mātakōkiri Project is an initiative that supports students to engage with science by linking science/pūtaiao to Māori language, culture and identity through students' local tikanga, whakapapa and stories. The project is an iwitanga-based science programme run by Te Taumata o Ngāti Whakaue Iko Ake Trust in their rohe for their students, whānau, teachers and schools.

A pilot will run through to July 2014 to build school science community partnerships that support school students' science learning, and test such a leadership and coordination role for strategic effectiveness to inform a wider system change in 2015-16. The aim is to develop sustainable linkages between the science education community and schools to make the most of New Zealand's collective strengths and resources.

Science Learning and Change Networks

Learning and Change Networks are communities of practice that provide an environment for the building of sustainable partnerships between families, whānau, iwi schools and kura to listen to student voice about what matters most for their learning and achievement. Together these communities co-construct responses to a learning challenge to enable accelerated progress towards equitable outcomes for priority groups and student achievement. In 2014 new networks will be established with a dedicated focus on student achievement in science.

Continuing STEM education for teachers

The Ministry of Education provides professional learning development (PLD) in both English-medium and Māori-medium to build teacher capability and confidence to deliver learning programmes in science/pūtaiao, technology/hangarau and mathematics/pāngarau.

Curriculum support materials

Quality teaching, learning and assessment are supported through a range of online and print publications. These focus on how to deliver personalised learning, develop authentic learning experiences for students and build partnerships between schools, teachers, students, families and whānau and communities to ensure diversity of STEM education and success for all learners. A growing body of literature signals the case for integrating quality teaching practices with technology to change knowledge[33].

Promoting STEM-related subjects and careers

There is a range of government activity in promoting STEM related subjects and careers.

- The 2014 Occupation Outlook included a STEM feature that identified the current and future demand for STEM-related careers.
- The Tertiary Education Commission (TEC) has worked with the tertiary sector to increase the numbers of skilled engineering technicians and engineering university graduates.
- TEC released its Youth Transitions Framework that focuses on more young people participating in learning areas of high growth and demand (eg STEM subjects).
- The Ministry of Education and TEC are working on the identification of STEM-related Vocational Pathways credits that will enable secondary and tertiary students to achieve foundation level credits for progression towards higher level STEM-related qualifications.
- Te Puni Kōkiri has increased Māori awareness of opportunities that exist in STEM and architecture and design through partnering with Te Rōpū Āwhina in the Victoria University on-campus support group for Māori and Pasifika students and producing the Māori Future Makers website which profiles Māori and whānau in non-traditional, knowledge intensive sectors.
- Callaghan Innovation[34] expects to spend $1.2m in 2014 on promoting STEM careers to students and their families through the Futureintech programme.

Publicly funded-activity to support science in schools

Universities, polytechs/institutes of technology and other tertiary education institutions have extensive relationships with schools, with a range of current initiatives between the tertiary sector and schools. Te Puni Kōkiri is also partnering with Auckland Uniservices through the LenScience programme to support teachers in up to 20 secondary schools in Auckland with high numbers of Māori students to deliver tailored science curriculums to meet the needs of Māori students.

Other government initiatives support the plan

Other government initiatives will contribute to delivering on this plan such as.

- Investing in Educational Success – Teaching and Leadership career pathways initiative which targets raising achievement through quality teaching and professional leadership offers an expanding environment in support of the principal objective of this plan.
- The New Zealand Qualifications review of qualifications – mandatory reviews of science qualifications and the review of tertiary teaching qualifications are taking place during 2014.
- Tertiary Education Strategy (TES) - The two most relevant strategic priorities in the TES for this plan are: Priority 1, delivering skills for industry; and Priority 5, strengthening research-based institutions. The TES emphasises the importance of tertiary institutions being more outwardly focussed, in particular, connecting learning to employment outcomes and encouraging providers to be more connected to industries and communities. The TES also prioritises science and technology.
- The Office of the Prime Minister's Chief Science Advisor (CSA), established by the government in 2009, helps to close the gap between the science community and the public. Analysis by the CSA[35] has resulted in the establishment of Departmental Science Advisors to lift the public services capabilities to ensure the greater use of robust and reputable research-derived knowledge in decisions that are important to the public.
- MBIE's Vision Mātauranga policy states that unlocking the science and innovation potential of Māori knowledge, people and resources will benefit New Zealand. For this reason the Vision Mātauranga policy is embedded across all priority investment areas. This plan supports the theme of building the capability of Māori individuals, businesses, incorporations, rūnanga, trusts, iwi, hapū, and marae to engage with science and innovation as an important step in unlocking the potential of Māori knowledge people and resources.

PART 3 Strategic Action Areas and Priority Actions

While section 2.6 outlined the government's progress towards encouraging and enabling engagement by New Zealanders with science and technology, more needs to be done.

In particular, further support is needed to help develop teacher confidence and science competencies through initial teacher training; continuing professional learning and development; and better links between practicing scientists and schools.

Continued support is also needed to encourage effective ways for the science sector and other science and technology communicators to engage with the public at all levels, including through two-way dialogue; and further support is needed for good practice, greater impact and improved coordination.

This section sets out 3 Strategic Action Areas (SAAs), each with a set of priority actions over the next three years to address these remaining gaps.

Strategic Action Area 1: The Education Sector

The principal goal of Strategic Action Area 1 is to support all young New Zealanders to be resilient learners with future-proofed skills to understand, assess and apply rapidly changing science and technology knowledge to their everyday lives. In addition, the Action Area is also designed to increase the number of such learners who move toward STEM-related career pathways. Strategic Action Area 1 will contribute to those related goals through a focus on

quality teaching and learning, and providing additional opportunities to enhance competencies, confidence and dispositions that grow scientific knowledge, curiosity and creativity in students in partnership with schools and kura, families, whānau and iwi and the science community.

The activities in Strategic Action Area 1 are focused on four key intervention sites: primary level education; secondary level education; the transition to further study/training or employment; and science leadership.

1. *Improve initial teacher education for increased science teaching competencies and competence*. Primary teachers are necessarily generalists. New research has shown that primary education is an important window of opportunity for imparting foundation curiosity and learning behaviours for learners' future attitudes and practices toward science and technology. To maximise this opportunity new primary teachers need the confidence and content knowledge to sustain student engagement and progress.

   Actions

   - The Ministry will work with initial teacher education providers, qualification accreditation bodies and relevant professional bodies to identify ways to lift the level of science content in initial teacher education. This could form a component of under-graduate qualifications for primary education, and would be targeted to lift the confidence of graduating teachers to teach science (teachers currently report limited confidence, particularly at years 7-8).

2. *Improve the quality and relevance of continuing professional learning and development opportunities for teachers in science and technology.*

   The Government spends more than $70 million every year on professional learning and development to support the development of a highly capable profession, and a professional learning and development system that builds the skills of teachers and education leaders, which in turn delivers measurable gains for students in science/pūtaiao, technology/hangarau and mathematics/pāngarau. The Minister of Education has appointed an Advisory Group with representatives from across the education sector to provide advice on the design of future professional learning and development across the compulsory schooling sector. The group will provide advice on what improvements should be made to the targeting of PLD to achieve a system-wide lift in student achievement; and provide advice on how changes could be implemented to achieve the maximum impact.

   Actions:

   - Update the Science, Mathematics and Technology teacher fellowship programme to include a 'school science leadership' component with a focus on science and technology teaching and leadership competencies
   - Increase the uptake and utilisation of the Science/Biotechnology Learning Hubs as a high-quality online repository of New Zealand science for teachers and students
   - Create a Science Skills in Education Initiative, which will support teachers to undertake science education and develop ideas for teaching science in a way that is both exciting and relevant to their learners. The network will coordinate support from local industry, and local and national government to support schools and teachers to undertake approved training from providers with a proven record of excellence in science teaching, for example primary teachers study courses in primary science teaching or expanding the current Sir Paul Callaghan Academy

initiative and schools receive a small subsidy to participate. This would boost teachers confidence in teaching science

- Create a Science in Industry programme where, during the school holidays, teachers who volunteer are invited to visit and work in local industries that represent likely science and technology employers for their students. Participants would be supported to reflect on the practical application of science in industry for their lessons plans, upscale Learning and Change Networks for science, and explore the development of virtual learning networks for science teachers on the Network 4 Learning portal. This will enable groups of schools to connect with the broader community whilst focussing on raising science literacy

3. *Encourage youth into science and technology-based careers*: Continue to develop more responsive educational pathways and raise awareness about the impacts of student subject choices, including on entrepreneurial thinking in the science and innovation sector. The relevance of science and technology learning to future careers options needs to be made clearer at an earlier stage for learners and potential careers should be highlighted.

   Actions:

   - ensure CareersNZ has meaningful engagement with schools' careers services to promote science and technology careers well before subjects become optional
   - continue to support talented school students through young achievers and travel awards
   - explore more strategic targeting of the Futureintech programme, and other potential changes to increase its impact
   - review and evaluate the pilot of the Science Education Leadership and Coordination role for merit to expand
   - continue work to develop and promote the uptake of information provision for learners about science careers
   - explore using the Youth Guarantee Networks to promote links between science industry and education providers to encourage young people towards careers in science
   - support schools, through Vocational Pathways, to redesign curriculum to recontextualise learning in a way that better meets learners needs, including science education
   - consider how to strengthen science literacy in senior secondary schooling particularly at Year 11
   - consider the future of the STEM feature in the occupational outlook
   - establish mechanisms to connect industry, local government, educators and the science community at a regional, industry or sector level

4. *Build and maintain meaningful linkages between science and technology educators and learners, and practicing scientists and technologists, both in the classroom and through opportunities that engage the wider community:* This action cuts across Strategic Action Areas 1, 2 and 3. Partnerships with universities, CRIs, private bodies, science organisations (such as museums, science centres, zoos, aquaria, observatories) and secondary-tertiary programmes that enable participants to experience tertiary-level educational activities, are all key for learning outside the classroom. These learning

experiences outside the classroom need to be integrated meaningfully within teaching and learning programmes.

Actions:

- Build and strengthen links between teachers, learners and practising scientists by promoting quality Learning Experiences Outside the Classroom.
- Identify the assessment standards on the National Qualifications Framework (levels 2 and 3) that will;
    - improve students access to experiential applied STEM learning opportunities
    - enable students to make informed choices about progression to higher level STEM related pathways
    - improve the visibility of STEM capabilities within assessment standards
- Provide a platform for Participatory Science that engages schools, community-based groups and organisations and practicing researchers in questions that are scientifically rigorous, locally relevant and pedagogically innovative. The platform includes central coordinator roles that will oversee the platform and be a conduit between learning environments and scientists (see annex 2 for a more detail on the new platform).

Strategic Action Area 2: Public engaging with science

The goal of this Strategic Action Area is to build a nationally supportive environment for public engagement in science and technology. It operates with Strategic Action Area 3 to encourage greater dialogue between the science sector and the public by helping move toward 'a more scientifically engaged public' and 'a more publically engaged science sector'.

In the immediate term, it will enhance the quality, breadth and depth of science communication to the public by the media, scientists, and organisers of national science and technology public events. In the longer-term, Strategic Action Area 2 recognises that the true culture change necessary to encourage and enable public engagement in science must start with young learners, their teachers, their families/whanāu and their communities.

1. *Support quality science journalism and blogging in the multi-platform media:* Print, television and online media (including socially networked media and blogging) are powerful tools for engagement with the public. This priority action will continue to harness the positive power of the media to help make science and the complexities of risk and scientific uncertainty more accessible.

   Action:

   - Enhance the role and reach of the Science Media Centre to support more training and outreach to science journalists to encourage responsible and insightful science news reporting and long-form analysis that is relevant to the New Zealand public.

2. *Support quality national public events on science and technology:* Events that bring science and technology to the general public have the potential to engage the public in science and technology in captivating and relevant ways. This action will support such events with a broad reach, extending beyond a local area.

   Action:

- Establish a contestable fund for nationally delivered one-off events that target the general public and would not proceed without government support.

3. ***Cross-referenced with Strategic Action Areas 1 and 2**, support parents and whānau to increase their engagement with science*: The development of parental/whānau and community involvement acknowledges and builds on the importance of parents and families/whānau and local communities as young learners' first mentors, while also providing an opportunity to encourage parents' engagement with science through community collaborative research opportunities that bring together practising scientists with schools and other community organisations on real-world questions.

   Action:

   - Provide a platform for Participatory Science (see annex 2 for more detail on the new platform). The platform will offer schools and their communities opportunities to participate in scientific research in projects with broad appeal, scientific value and pedagogical rigour that resonate with the community.

Strategic Action Area 3: Science engaging with the public

Strategic Action Area 3 complements Strategic Action Area 2 because there cannot be a scientifically engaged public without there also being a publicly engaged science sector. This Strategic Action Area recognises the important role that the science sector plays in ensuring the public relevance of research, whether through saleable innovations or policy-relevant results. Publicly funded scientists have a social responsibility to share some level of knowledge where it's applicable. We also look to science for useful new technologies and evidence-based guidance on society's most pressing issues.

1. *Ensure that publicly funded scientists continue to employ leading edge knowledge and international best practices to engage relevant public(s) in identifying priority research questions and usefully disseminating results.*

   Actions:

   - Public research funding bodies will review and update the knowledge translation expectations attached to direct purchase /grants for research and contracts, and assess the current state of publicly-relevant knowledge transfer practice among funding recipients. Results of this exercise can be used to inform training material for grantees and future decisions about the research funding
   - Build on the success of the public engagement process used to identify the National Science Challenges by considering the the adoption of a similar approach to engaging the public in the implementation phase of the National Science Challenges
   - Royal Society of New Zealand and the Prime Minister's Chief Science Advisor will work with the scientific community to develop a Code of Practice for Scientists that enshrines their public responsibilities. A recent model of such a commitment is the Japanese Council of Science's recently updated Code of Conduct of Scientists, which outlines not only the responsible conduct of research but also the social responsibility of scientists to engage with the public and policy makers based on their expert knowledge.
   - Continue to ensure that scientists' excellence is acknowledged and showcased through the Prime Minister's Science Awards.

2. *Ensure that emerging scientists and technology researchers have the basic communication skills to make their research accessible to relevant audiences beyond their peer community.*

   Action:

   - Work with the tertiary sector to identify ways to ensure that all emerging science and technology researchers have access to training that supports engagement and the dissemination of their knowledge to non-academic audiences.

3. ***Cross-referenced with Strategic Action Areas 1 and 2**, support scientists to contribute meaningfully to schools and communities, while advancing their scientific output, by enabling their involvement in participatory research.*

   Action:

   - Provide a platform for Participatory Science (see annex 2 for more detail on the new platform). The platform will match scientists and members of schools or community organisations seeking to take part in community-initiated and scientist-initiated research.

PART 4 Implementing and evaluating the strategy

Addressing the challenges described in the plan are longer term issues that will require a commitment to sustained change. It will also require us to learn and modify as we go. For these reasons, the government has asked the Science in Society Reference Group to reconvene in 2015 to review progress and advise on any modifications to the priority actions.

4.1 Timeframe

The plan proposes actions for the next three years from 2014 to 2017.

Some actions are already being progressed as they continue or enhance effective existing actions. Enhancing the role of the Science Media Centre and the Ministry of Education's pilot of a strategic leadership and coordination role for better connecting schools and the science sector are examples of these actions.

The plan also includes actions that can be implemented in the short to medium term. For example, the participatory science platform and the contestable fund for nationally delivered one-off events can be developed in 2014/15 for implementation in 2015/16.

Finally, some of the proposed action areas for the education sector require a longer term (Year 1-6) approach. This will ensure that there is sufficient time to address changes around, for example, initial teacher education, and linking classrooms to the professional science community. These actions will help inspire and provide authentic learning opportunities of relevance and interest to students.

4.2 Evaluation Framework

A monitoring and evaluation programme will be developed to track progress in delivering on this plan and inform further development.

Annex 1: Process for developing this plan

This plan was developed by the Ministry of Business, Innovation and Employment, the Ministry of Education and the office of the Prime Minister's Chief Science Advisor on behalf of the Government.

A Science in Society Reference Group of experts provided advice to assist the government to develop this plan. The members of the Group are:

Professor Sir Peter Gluckman (Chair)	Professor Sir Peter Gluckman is the Prime Minister's Chief Science Advisor. He was the founding Director of the Liggins Institute and is one of New Zealand's best-known scientists. He is internationally respected for his work promoting the use of evidence in policy formation and the translation of scientific knowledge into better social, economic, and environmental outcomes. Professor Sir Peter is a Fellow of The Royal Society (London), the Commonwealth's most prestigious scientific organisation. He is the only New Zealander elected to the Institute of Medicine of the National Academies of Science (USA) and the Academy of Medical Sciences of Great Britain. In 2009 he became a Knight of the New Zealand Order of Merit for services to medicine. In 2001 he received New Zealand's top science award, the Rutherford Medal.
Professor Jim Metson (Deputy Chair)	Professor Jim Metson is Chief Science Advisor to the Ministry of Business, Innovation and Employment. He has a PhD in Chemistry from Victoria University of Wellington and is Deputy Dean of Science at the University of Auckland, Professor in its School of Chemical Sciences, and Associate Director of the University's Light Metals Research Centre. He has a background in building science capability, and has led the formation of several major interdisciplinary research centres at the University.
Professor Alister Jones	Professor Alister Jones is Deputy Vice-Chancellor of the University of Waikato. He was Dean of Education and Research Professor and Director of the Wilf Malcolm Institute of Educational Research at the Faculty of Education. He has managed and directed research projects that have informed policy, curriculum, science and technology education and teacher development in New Zealand and internationally. He was awarded the New Zealand Science and Technology Medal. He is Co-Director of the Science Learning Hubs and co-chairs an APEC working group on science and mathematics education.
Jacquie Bay	Jacquie Bay is the founding Director of LENScience, an innovative science education programme within the Liggins Institute. She co-developed the award winning LENScience Connect learning platform for science education.
Hikitia Ropata	Hikitia Ropata is the General Manager Strategic Development at Careers NZ. She is also a member of the Export Industry Skills Analysis Advisory Group. She has worked across both social and economic policy and delivery spaces. Her specific interest is in getting more New Zealanders interested and participating in science and technology careers, particularly Māori and Pasifika. She is of Ngāti Toa, Ngāti Raukawa, Te Ati Awa, Ngāti Porou descent.
Peter Griffin	Peter Griffin is the founding manager of the Science Media Centre and the founder and editor of Sciblogs. He was Technology Editor of the New Zealand Herald, technology columnist for the Herald on Sunday and a commentator for TVNZ, Radio New Zealand and Radio Live. In 2012 Peter was a Fulbright-Harkness Fellow undertaking research in the US looking at centres of excellence in public interest journalism.
Richard Meylan	Richard Meylan is Senior Manager Public Engagement and Education at the Royal Society of New Zealand and formerly was Principal Adviser to the New Zealand Ministry of Research, Science and Technology. He is a former teacher and in 2011 spent nine months on a sabbatical to the International Council for Science in Paris.

Lee Parkinson	Lee Parkinson is a communications consultant. A Chartered Marketer and Fellow of the Chartered Institute of Marketing, he was recently Managing Partner of Ikon Communications. Lee attended the Transit of Venus forum and was consulted in the development of communications approach for Great New Zealand Science Project.
Dr Steven Sexton	Dr Steven Sexton is President of the New Zealand Association of Science Educators. He is a senior lecturer in Science Education at the College of Education at the University of Otago. He was a primary school teacher.
Dr Jan Giffney	Dr Jan Giffney is Head of Science at St Cuthbert's College, Auckland. She was honoured with a prestigious professional award – the Independent Schools of New Zealand Excellence in Teaching Award for Exceptional Professional Performance for Years 11–13. She is also an experienced chemistry teacher with a long history of involvement in the NZ Chemistry Olympiad programme.
Ally Bull	Ally Bull leads the science education team at New Zealand Council for Educational Research. She has expertise in research on science education and is co-convenor of the NZ Association for Research Education Science education Special Interest Group.
Angela Christie	Angela Christie is Director – Schools at the Institution of Professional Engineers of NZ. She is responsible for the development and implementation of the Futureintech Project – a government-funded careers promotion initiative. She also manages the IPENZ school programmes.
Evan Brenton-Rule	Evan Brenton-Rule is winner of the 2013 Eureka Award for Young Science Orators for his presentation about a solution for the threat posed by invasive species in New Zealand. Evan is studying towards law and science degrees at Victoria University of Wellington.

The National Science Challenges Panel and [to come] provided feedback on a draft of the plan.

Annex 2: Description of new initiatives

Participatory Science Platform

The Participatory Science platform builds on citizen science approaches and enhances them through aspects of citizen engagement used in community-based participatory research. Participatory Science is a method of undertaking scientific research where volunteers can be meaningfully involved in research in collaboration with a professional scientist and builds on international models of engagement.

The Participatory Science platform is built on four core components and incorporates Matauranga Māori:

1. A public engagement process that seeks ideas for participatory science projects from the community and from practicing researchers;
2. A managed process for evaluating these ideas for pedagogical and scientific quality and for ensuring their practicality and relevance to the participating community;
3. A web-based match-making process between interested community-based partners and university or CRI-based scientists; and
4. A resource for teachers and other learning leaders to assist in developing their projects to robust standards.

The goal is to involve schools and their communities in projects with broad appeal, having both scientific value, pedagogical rigour, and that resonate with the community. We are testing several ideas for projects of national significance that would integrate with the National Science Challenges and be national in reach.

The website will serve as a match-making tool between scientists and members of the schools or community organisations seeking to take part in a research project by offering a platform for community-initiated and scientist-initiated research.

A multi-sectoral management and review panel will be established to maintain quality control over the programme and advise on any research ethics requirements.

All projects must have an institutional home which is the responsible coordinator. This could be a school, museum, zoo, science centre, research institute or university.

In general, it is expected the projects will be of minimal cost. However, to enable more sophisticated projects, limited one-time seed grants will be made available to help foster a meaningful level of community involvement. The seed-grants will part-fund professional researchers and community groups together planning the research question, data collection, analysis and knowledge translation strategy for the project.

The projects will be offered as opportunities for schools and their communities to participate in scientific research as a way to enhance their science learning programmes through stronger links to out-of-school learning environments and expertise, and more relevant and valuable science learning for students. Schools would self-direct their involvement and fund it in the same way that they currently fund curriculum support resource or, in the case of scientist-initiated projects, funded through scientists' own research funds.

A multi-media campaign will accompany the launch of programme, and a dedicated website/social media site will provide a sustained channel of communication for ideas that continue to emerge. It will build on the momentum created by the *Great New Zealand Science Project* and leverages the legacy of that project, including its Facebook page.

DRAFT approved by Ministers for seeking feedback from key stakeholders 15/4/14

References

[add hyperlinks in webpage]

1. Public Engagement in Science and Innovation
   http://mako/OTCS/llisapi.dll?func=ll&objaction=overview&objid=9352461

2. Science Education
   http://mako/OTCS/llisapi.dll?func=ll&objaction=overview&objid=8973336

3. STEM skills and careers

   Briefing: http://mako/OTCS/llisapi.dll?func=ll&objaction=overview&objid=12685437

   International policies paper:
   http://mako/OTCS/llisapi.dll?func=ll&objaction=overview&objid=12684255

Glossary

What do we mean by 'engagement'?

We use the term 'engagement' to mean the acquisition and application of multiple types of STEM knowledge[36], by multiple kinds of audiences and applied to various purposes. It implies an improved and productive social relationship between the science sector and society that will lead to its responsible application for the social, environmental and economic benefit of New Zealanders.

Engagement in…

- *generating knowledge* is about knowledge users, including the public, being enabled to help identify issues requiring science input so that public science research is more relevant and stands to have more meaningful impact. It is also about the public being part of the research itself, including through citizen science.

- *acquiring knowledge* is about the public, including and especially compulsory level students acquiring the STEM skills and knowledge needed to develop a career in science and/or engage in much needed and ongoing civic discourse about the application of scientific knowledge.

- *assessing knowledge* is about applying an increasingly sophisticated understanding of the what science can (and cannot) provide in the search for solutions to today's pressing problems. Assessment requires an understanding of risk and probabilities associated with both the issues themselves and their scientific responses. Citizens, businesses and governments and the science community are all stakeholders in these critical debates.

- *applying knowledge* is about making the best use of what we know, including the responsible and evolving use of or limiting of new technologies or novel applications of extant technology.

This definition of engagement reflects a fresher approach through a necessary mix of what has been called 'public understanding of science' or 'science literacy' and of 'public engagement in science'.

Over the past two decades, the place of science in societies has changed from a focus on an undifferentiated 'public' that was illiterate, apathetic or hostile towards science and technology (known as "public understanding of science[37]) towards an awareness of multiple contextualised audiences for science and the distinct ways that they engage with it (known as "public engagement in science) [38].

In the USA and Europe in the [1980's and 1990's] there was a one-directional focus by governments on remediating the presumed public knowledge deficit. In recent years those countries have identified that public perceived apathy or hostility toward research or technology is more about social values and citizens' trust than it is about public knowledge of scientific facts. They have shifted their focus on creating context appropriate opportunities for dialogue and input into decisions about what society wants science to do for us all[39].

Science includes social sciences. Science interrogates the "real things" or phenomena of the natural world in order to construct explanations of them, that is, to know the world.[40]. The New Zealand Curriculum describes ***science*** as "a way of investigating, understanding and explaining our natural, physical world and the wider universe." It involves generating and testing ideas, and

gathering evidence through various means which include observation, investigation, modelling and communication and debate with others to develop scientific knowledge, understanding and explanations.

Technology. Technology intervenes in the world to solve problems, meet needs or desires, that is, to create part of the made world[41]. The New Zealand Curriculum describes ***technology*** as "intervention by design: the use of practical and intellectual resources to develop products and systems that expand human possibilities by addressing needs and realising opportunities. Adaptation and innovation are at the heart of technological practice...which is never static".

STEM is the internationally recognised term that refers to subjects or areas of learning, namely Science, Technology, Engineering and Maths, which are used broadly and are inclusive of all levels of learning.

STM refers to school subjects (science, technology and mathematics) because engineering is taught only at tertiary level.

Science knowledge means knowledge of science and knowledge about science. Certain audiences will specialise in knowledge 'of', but basic knowledge 'about' science is broader and is an important tool of 21st century citizenship for engaged and equitable civic discourse on today's most pressing societal concerns. We also acknowledge that 'knowledge' may also mean the science community's knowledge of various public audiences and how to connect with these to make their science relevant.

[1] The 'leadership challenge' recommended by the National Science Challenges Panel in its report *Report of the National Science Challenges Panel, 27 March 2013* was called the 'Science and Society leadership challenge. This plan uses 'Science in Society' is intended to convey the message that science is part of, as opposed to additional to, society.

[2] Immigration NZ: www.immigration.govt.nz/essential skills.htm.

[3] Programme for International Student Achievement *Draft Science Framework.p3.*

[5] *Madsen, JB. 2010. The Anatomy of Growth in the OECD since 1870. Journal of Monetary Economics, v57(6) pp 753-67.*

[6] New Zealand Government *Business Growth Agenda: Progress Report 2013.*

[7] Ministry of Business, Innovation and Employment *Occupation Outlook 2014, p7.*

[8] Ministry of Business, Innovation and Employment *Occupation Outlook 2014, p8*.

[9] Ministry of Business, Innovation and Employment *Occupation Outlook 2014, p7*.

[10] New Zealand Curriculum 2007.

[11] *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies'* OECD Publishing, 2012. http://dx.doi.org/10.1787/9789264177338-en,

[12] http://www.careers.govt.nz/plan-your-career/helping-young-people-make-decisions/what-things-influence-a-young-persons-career-decisions/ and 'STEM Careers Awareness Timelines: Attitudes and ambitions towards science, technology, engineering and maths' Jo Hutchinson, Peter Stagg and Kieran Bentley, University of Derby, 2009. www.derby.ac.uk/files/icegs_**stem**_careers_awareness_timelines.pdf

[13] This survey, *Science and the General Public 2010,* was commissioned by the Ministry of Research, Science and Technology. Similar surveys were also commissioned in 2002 and 2005.

[14] Rosemary Hipkins, '*Public Attitudes to Science: rethinking outreach initiatives' New Zealand Science Review* 67.4, 2010, p109. The 44% of New Zealanders with a detached interest in science are described in the survey as a 'mainstream group'. This group understands that science is important, but they do not consider it is relevant to their busy, everyday lives. They perceive that: science information lacks relevancy; they receive too much or too little information; they lack trust in scientists and lack understanding of career pathways for their children / young relatives.

[15] For example, Eurobarometer 73.1: Science and Technology Report 2010, European Commission, 2010 and Public Atitudes to Science 2011: Main Report. Ipsos Mori Social Research Institute/Department of Business, Innovation and Skills (UK), May 2011. http://ipsoso-mori.com/Assets/Docs/Polls/sri-pas-2011-main-report.pdf

[16] 35% of New Zealand adults have a secondary qualification and a further 21% have a tertiary qualification *New Zealand Census 2013.*

[17] This includes: $927m from Vote Science and Innovation; $313m from Vote Education; $98m from Vote Primary Industries and $18m from other government Votes.

[18] The appropriations in Vote: Culture and Heritage for 2013/14 are $134,417m (for public broadcasting services) and $33.094m (for museum services). The $33.094m (for museum services) funds the Museum of New Zealand Te Papa Tongarewa.

[19] Rowe et al, 'Difficulties in evaluating public engagement initiatives: reflections on an evaluation of the UK GM Nation public debate about transgenic crops' *Public Understanding of Science,* v14 (2005), pp331-352.

[20] [To come].

[21] Immigration NZ: www.immigration.govt.nz/essential skills.htm.

[22] Ministry of Business, Innovation and Employment *Occupation Outlook 2014*, p8.

[23] *Inspiring Australians*

[24] www.ipenz.org.nz/ipenz/forms/pdfs/**NEEP**_Project_**Report**.pdf.

[25] http://www.wipo.int/export/sites/www/freepublications/en/economics/gii/gii_2013.pdf, page 290 School life expectancy, primary to tertiary education (years) | 2010

[26] From 2008-2010 students with more than 14 credits in science rose from 73.1% to 73.5% and then dropped in 2011 and 2012 to 71.4% and 71.6% respectively.

[27] Trends in International Mathematics and Science Study.

[28] OECD, *Programme for International Student Assessment 2012.*

[29] Prepared by the Ministry of Education from data from the Programme for International Student Assessment.

[30] Hipkins, R and Bolstad R. 2005. *Staying in Science. Students' participation in secondary education and on transition to tertiary studies*; and the follow-up study *Staying in Science 2* (by Hipkins, R, Roberts, J, Bolstad R and Ferral H. 2006) NZ Council for Educational Research. Also NMSSA and Education Review Office *Science in Years 5 to 8: Capable and Competent Teaching* (May 2010) 31/05/2010.

[32] In 2013/14 this appropriation was $8.969m

[33] For example, Fullan, M. 2012 Stratosphere.

[34] Callaghan Innovation is a Crown Agent. Its main objective is to support science and technology-based innovation and its commercialisation by businesses, primarily in the manufacturing sector and services sector, in order to improve their growth and competitiveness.

[36] We use the OECD definition of science knowledge' to mean knowledge *of* science and knowledge *about* science. Certain audiences will specialise in knowledge 'of', but basic knowledge 'about' science is broader and is an important tool of 21st century citizenship for engaged and equitable civic discourse on today's most pressing societal concerns. We also acknowledge that 'knowledge' may also mean the science community's knowledge of various public audiences and how to connect with these to make their science relevant.

[37] Jasanoff, S. *A mirror for science.* In: Public Engagement in Science: Special Issue Vol. 23(1) 21-26. 2014

[38] Jasanoff, S. *A mirror for science.* In: Public Engagement in Science: Special Issue Vol. 23(1) 21-26. 2014

[39] Jasanoff, S. *A mirror for science.* In: Public Engagement in Science: Special Issue Vol. 23(1) 21-26. 2014

[40] France and Compton *Bringing Communities Together.*

[41] See footnote 33.

Science for, by, and with New Zealanders

A national strategic plan for science in society 2014-2017

DRAFT STRATEGIC PLAN FOR COMMENT

Contents

Ministers' foreword

[To be drafted]

Steven Joyce
Minister of Science and Innovation

Hekia Parata
Minister of Education

Executive summary

The nature of science and its role in advancing society's interests has changed in recent decades. It is clear that science and the knowledge and innovation that flow from scientific progress have a central role in creating and defining our future. But science can no longer be perceived of as being somehow isolated from the rest of societal functions. Rather, it is well embedded in everything we do. Society has as much stake in what research is undertaken, why it is done and how it gets used as those who generate the knowledge. Understanding and making the most of this relationship between science and society is critical to a vibrant and healthy nation.

Many of today's most complex decisions (e.g. on public health, natural resources stewardship and communications technology) require us all to weigh scientific evidence and social values. New Zealanders should feel encouraged and equipped to engage in the key questions facing our society now and in the future. The Government's goal of economic growth through an innovation society drives the need for an increasingly science, technology, engineering and maths (STEM) competent workforce.

This plan has been developed in response to the Science in Society 'leadership challenge'[1] recommended by the National Science Challenges Panel. The Panel saw it as "the most important challenge to address" and central to the success of the National Science Challenges. In May 2013, the Government formally accepted the leadership challenge.

The government's primary objective for Science in Society is to 'encourage and enable better engagement with science and technology across all sectors of New Zealand' in order to deliver:

- a more scientifically and technologically engaged public and a more publically engaged science sector; and
- more science and technology competent learners choosing STEM-related career pathways.

In the longer term it is anticipated that progress towards these outcomes will contribute to New Zealand's economic growth and social and environmental well-being through:

- a greater number of New Zealanders with the skills needed to support creativity, innovation and knowledge uptake and use;
- publically funded science and technology which responds to the needs of New Zealanders; and
- New Zealanders make more informed decisions on issues of importance to 21st century life.

A survey of public attitudes to science identifies that about half of New Zealanders are actively interested in science and the other half did not recognise the relevance of science in their everyday lives (44%) or were disengaged (9%). There is limited evidence on the level and effectiveness of the engagement of the science sector with the public.

Demand for STEM skills (for scientists, technologists, engineers, health and ICT professionals[2]) is expected to grow strongly. More students are graduating with degrees in natural and physical sciences and engineering. New Zealand school student performance in science is declining.

The challenges ahead are:

- increasing the engagement of New Zealanders, across all sectors, with science and technology and increasing the effectiveness of the science sector's engagement with the public; and
- increasing the numbers of learners with STE competencies to meet the needs of 21st century citizenship and labour market.

These are long-standing challenges that will take time to address. The plan sets out a direction for the next 10 years and actions for the next three years.

Some action has been taken towards encouraging and enabling engagement by New Zealanders with science and technology. However, to deliver on the objectives and outcomes in this plan a step change is needed.

This plan will focus on three Strategic Action Areas and one integrating Strategic Action:

- ***Strategic Action Area one***: further enhancing the role of the education sector
- ***Strategic Action Area two***: public engagement with science and technology
- ***Strategic Action Area three:*** science sector engaging with the public
- ***Integrating Strategic Action:*** Participatory Science

The three Strategic Action Areas are interconnected, as each supports actions in the other, while a key component of this plan is the Participatory Science Platform, which operationally and strategically joins all three. Indeed, the advice of the Science in Society Reference Group is that any action in the education sector must be complemented by support from the wider school community. Enhancing public engagement with science and technology cannot be separated from encouraging scientists to engage effectively with the public. This plan addresses the barriers and enablers to creating a more 'publically engaged' science sector together with a more 'scientifically engaged' public.

This plan acknowledges and recognises the importance of mātauranga Māori to build cultural confidence and identity, and how, through this, New Zealand can grow its skills and generate innovation and creativity. Mātauranga Māori is Māori knowledge that is dynamic building from earliest traditions to future knowledge. Each of the three Strategic Action Areas will be developed in ways that respect whānau, hapū and iwi as the key conduits of mātauranga Māori, and focus on realising the potential gain for New Zealand through building Māori capability in science and technology to support Māori management of natural resources and development.

MBIE's Vision Mātauranga policy states that unlocking the science and innovation potential of Māori knowledge, people and resources will benefit New Zealand. For this reason the Vision Mātauranga policy is embedded across all priority investment areas, and as such forms a core component of the Science in Society approach to Māori. [MoE to add text]

As this is New Zealand's first Science in Society strategic plan in 2015 [the growing network of departmental science advisors (insert maori name for it) chaired by the Prime Minister's CSA and] the Science in Society Steering and Reference Groups will assess progress on the plan and advise government on any modifications needed to the actions to better deliver on the outcomes.

The Ministry of Business and Innovation and the Ministry of Education, together with the Office of the Prime Minister's Chief Science Advisor, will coordinate implementation of the plan by

government agencies, iwi and other sectors including the education, science, business and museum sectors. They will also lead a process of engagement with the public on the plan and the actions in it.

The plan recognises the importance of maths skills as part of the overall package of STEM skills. However, it does not specifically address increasing the supply of students with maths competencies as this is being addressed by the literacy and numeracy taskforce.

PART 1 Setting the Scene

Science and technology are critical components of society's efforts to enhance standard of living through economic growth and enhanced social conditions, while protecting the environment. Today, there is a recognition that science is embedded in the many decisions societies must make -- whether in public policy, business or individual lives. Societies with strong "[knowledge-based] capital[3]" are sustaining more innovative economies and there is a greater awareness of both the opportunities and limits of science in development and wellbeing. Science is central to the many global challenges we face (from climate change to an aging and urbanising population, for instance). The Government recognised this, and in 2009, it established the Office of the Prime Minister's Chief Science Advisor (PMCSA) to assist in progressing understandings of the role of science both in government and by the public. Progress was revisited as a result of the work of the National Science Challenges Panel, which the PMCSA chaired.

1.1 The National Science Challenges and the Leadership Challenge

Following significant public engagement in early 2013, the National Science Challenges Panel recommended a set of national science challenges to address our most pressing health and environmental issues, and to advance our economy through innovation. The Panel also recommended a 'Science in Society leadership challenge' that they saw as "the most important challenge to address" if New Zealand is to advance through the responsible application of science and innovation and benefit optimally from its investment in scientific research. The Panel considered the 'Science in Society leadership challenge' to be central to the success of the National Science Challenges.

The 'Science in Society leadership challenge' asked government to take a lead in facilitating better engagement with science in New Zealand in four distinct but interrelated areas:

1. Science, technology, engineering and maths (STEM) education in primary and secondary schools.

2. 'Public understanding of science', including both the potential and the limits of scientific knowledge and managing uncertainties. Here, 'public' is understood in a pluralistic sense and necessarily includes the elected representatives and public servants that work in the interest of the New Zealand public.

3. Early engagement by citizens and other knowledge users on the implications of new technologies and novel applications of existing technology, and to help ensure the public relevance of New Zealand's science and research agenda.

4. National capacities in technology assessment, risk forecasting and using this in developing societal consensus in using and limiting technologies.

In May 2013, the Government formally accepted the 'Science in Society leadership challenge', with the Minister of Science and Innovation and the Minister of Education subsequently announcing development of this strategic plan in November 2013. In order to manage the scope of the plan the technology assessment and risk forecasting area is not addressed in the plan at this stage. Annex 1 sets out the process used for developing this plan.

1.2 Methodology for developing this plan

This is the first Government strategic plan for Science in Society.

The plan sets out the objectives and outcomes the Government wishes to achieve for Science in Society over the next 10 years. It sets out the available evidence on where New Zealand is at now and identifies the challenges that need to be addressed. It concludes by setting out a three-year plan of action to make progress towards the objectives and outcomes.

1.3 Scope of the plan

The plan focuses on supporting and equipping New Zealanders to engage in the key questions facing society and the supply of STE skilled people through the primary, secondary and tertiary education system. The plan does not cover the supply of maths skills and demand for STEM skills as these issues are being addressed through the Business Growth Agenda and literacy and numeracy taskforce. It does not address the government's current and proposed future priorities for its public science investments as this is covered by the National Statement of Science Investment. It also does not address adult maths literacy as the Government is addressing these issues through initiatives including the Tertiary Education Commission's Adult Literacy and Numeracy Implementation Strategy.

1.4 Audiences

The plan is addressed to all New Zealanders. To be effective, it is important to be specific about target audiences where strategic actions can make the most difference. In particular, the plan recognises that there are certain stakeholders in our social relationship with science that are truly 'agents of change.' These are:

- *Students, teachers and the compulsory learning sector*: today's learners are tomorrow's decision-makers who will engage in increasingly complex societal issues where science and technology may be either a cause or a solution and New Zealand needs a skilled workforce to push the boundaries of enquiry and innovation in an increasingly knowledge-led global economy.

- *Parents, whanau and communities:* important learning environments are in homes, communities and schools/kura across New Zealand, where an engagement with science and technology is role-modelled to our learners.

- *Business, especially science and technology-led businesses:* we need innovative science and technology-led businesses to grow our economy and employ skilled workers and a vibrant business sector to inspire future creators of science and technology-led businesses.

- *The public sector and government*: one way in which the public engages with science is through the decision-makers it elects. The relationship between elected officials, the public sector and New Zealanders is built on trust that decision-makers consider the best available evidence in public policy decisions.

- *Communicators of science and technology, including media, internet, museums, zoos and science centres*: many New Zealanders get their information about science and technology through reporting by the media and on the internet and visits to museums, zoos and science centres. We need accurate, contextualised information presented in an engaging way.

- *The science community:* teachers, students, the public, businesses, the media, public servants and government decision-makers should not be expected to identify, digest, analyse and act on raw scientific knowledge. To be relevant and useful, knowledge needs to be made accessible and contextualised. The science community (including

funders, researchers and trainees) needs to be enabled to share better and in some cases 'translate' the knowledge it is producing.

1.5 Key definitions

What do we mean by 'science', technology and STEM?

Science is a set of formal processes that interrogates the "real things" or phenomena of the natural and social world in order to construct explanations of them, that is, to know the world.[4] It describes a way of thinking about the world, a creative process which generates knowledge and the ability to think critically about that knowledge. The New Zealand Curriculum describes ***science*** as "a way of investigating, understanding and explaining our natural, physical world and the wider universe." It involves generating and testing ideas, and gathering evidence through various means which include observation, investigation, modelling and communication and debate with others to develop scientific knowledge, understanding and explanations.

Science knowledge means both knowledge of the processes, methods, and facts of science on one hand, and knowledge about science's applications and limitations on the other. Certain audiences will specialise in knowledge 'of', but basic knowledge 'about' science is broader and is an important tool of 21st century citizenship and public discussion on today's most pressing societal concerns. This has been referred to as 'critical science literacy[5]'. We also acknowledge that 'knowledge' may also mean the science community's own knowledge of various public audiences and how to connect with these to make their science relevant.

Technology intervenes in the world to solve problems, meet needs or desires, that is, to create part of the made world[6]. The New Zealand Curriculum describes ***technology*** as "intervention by design: the use of practical and intellectual resources to develop products and systems that expand human possibilities by addressing needs and realising opportunities. Adaptation and innovation are at the heart of technological practice...which is never static".

STEM is the internationally recognised term that refers to subjects or areas of learning, namely science, technology, engineering and maths, which are used broadly and are inclusive of all levels of learning. Often, the acronym is used as shorthand to denote the family of numerate subjects, even when one or more are not considered. In the plan, we distinguish deliberately between **STEM** and **STM**, which refers to compulsory level subjects (science, technology and mathematics) because engineering is taught only at tertiary level. **STE** refers to science, technology and engineering subjects.

What do we mean by 'engagement'?

Engagement can and should be a range of things for different people and different times, and is dependent upon purpose.

The goal of 'engagement' is to recognise and enable the role that we all have in understanding and informing the questions that we need science to address and what we do with the new knowledge that science produces.

In some instances, this is through the opportunity to learn in a more hands-on and relevant way that can help shape our attitudes and decisions. In other situations, it is a participatory tool for a more open approach to research and for making decisions about how to use the information it produces. This is one way that a stronger relationship between science and society can be developed.

For the public (including government) 'engagement' means the acquisition and application of multiple types of STEM-knowledge by multiple kinds of audiences for various purposes.

For the science sector it involves communicating new knowledge clearly for different users, as well as undertaking research that responds to the knowledge needs of society.

Taken together these characteristics of 'engagement' imply an improved and productive social relationship between the science sector and wider society that will lead to the responsible application of knowledge for the social, environmental and economic wellbeing of New Zealanders.

Thus, in this document, the focus is on engagement in…

- *acquiring knowledge*, which is about the public, including and especially compulsory level learners acquiring the STE skills and knowledge needed to develop a career in science and/or to engage in much needed and ongoing public conversations about the application of scientific knowledge and technology.

- *generating knowledge*, which is about knowledge users, including the public, being enabled to help identify issues requiring science input so that public science research is more relevant and stands to have more meaningful impact. It is also about the public being part of the research itself, including through opportunities in Participatory Science.

- *applying knowledge*, is about being enabled to make the best use of what we know, including the responsible and evolving use of or limiting of new technologies or novel applications of extant technology.

This definition of engagement reflects a fresher approach through a necessary mix of what has in the past been called 'public understanding of science' or 'science literacy' and of 'public engagement in science'[7].

PART 2 Making the Case

2.1 Why Science in Society matters

21st century life is driving the need to increase our engagement with science and technology

Many of today's toughest decisions at local, national and international levels – about public health; natural resources stewardship or new and emerging technologies for instance – require all of us to weigh both scientific evidence and social values. The National Science Challenges are science priorities that respond to the most important, national scale issues and opportunities identified by science stakeholders including the New Zealand public. Many of these and other challenges we face today and into the future will require creative and innovative solutions that have a basis in scientific discovery and technological application[8]. New Zealanders should feel encouraged and equipped to engage in the key questions facing our society now and in the future. [Paragraph deleted]

It is important to recognise that science is often at the heart of challenging social, environmental and economic issues – both as a solution to, but sometimes as a cause of the issues we face today.

The production and application of scientific knowledge and new technologies often imply trade-offs that we need to weigh carefully: how to prioritise research dollars; the potential for unintended consequences; and how much uncertainty society is willing to tolerate. These are complex issues for society to consider which no one group, such as scientists, government or businesses, should make on behalf of New Zealanders without their input.

However, addressing such questions requires 'social licence' for action to be taken. 'Social licence' is never guaranteed and depends upon an environment of mutual understanding and transparent and deliberate communication between the public and science community.

This plan is the Government's first-ever attempt to create the environment needed for this to occur by supporting change across the many sectors that can have impact over the next several years.

The goal of an 'innovation' society is driving the need for an increasingly STEM competent workforce

New Zealand's economic and social wellbeing depends on the productivity and competitiveness of the economy and the knowledge we have to help make informed decisions as a society. Innovation that leads to increased productivity and promising solutions to society's most pressing concerns is increasingly being seen around the world as an important way to generate economic growth and improved living standards[9].

The Government is committed to developing an 'innovation society' by materially lifting New Zealand's long-run productivity growth while maintaining our high rate of labour force participation[10], and by ensuring that we use the knowledge produced here and elsewhere to improve the policies and practices that affect us all. To do this, New Zealand needs a high performing and responsive science and innovation system and skilled people who can problem-solve and create and deliver high-value products and services for sustainable economic, social and environmental wellbeing. We also need businesses, policy makers and citizens that are ready to absorb and apply new ideas and approaches.

Our science system – particularly the tertiary education organisations that undertake research-led teaching – has a vital role in educating a future generation of scientists with the advanced science skills that are needed in leading-edge businesses. New Zealand has to be seen internationally as an 'innovation destination'. We must be able to attract and retain the right talent at the right time to contribute to our vital science. Attracting overseas and domestic investment in our research is also important for our economic growth.

A creative and innovative culture and a wide range of skills are needed for innovation, societal advancement and sound environmental stewardship. Internationally STEM skills underpin the development of new practices and technologies, the application of existing technologies and the development of new, high-value products[11]. STEM skills and competencies also underlie growth in many industries, such as IT-related industries[12] and are highly transferable across industries[13].

STEM skills, like other kinds of skills, are acquired by individuals over time and in a wide range of ways. They need to be developed as part of the key competencies for life-long learning[14]. An individual with higher levels of competency has a much lower likelihood of experiencing both economic and social disadvantage than an individual with lower competency levels[15].

Students' career choices are influenced beyond school by family, whānau, iwi and the wider community, with parents providing the most important influences[16]. Greater community engagement with science and technology could increase the value students and their family or whānau place on the opportunities STEM subjects offer as career pathways.

The Ministry of Education is focused on ensuring that the education system delivers on the Government's key goals of improved outcomes for all New Zealanders, and stronger economic growth for New Zealand. It is the lead agency on boosting skills and employment. Our ultimate goal is to equip young people with the skills to live a fulfilling life and contribute to New Zealand's economic prosperity.

The Ministry of Business, Innovation and Employment (MBIE) aims to grow New Zealand for all. New Zealand's economic and social wellbeing depends on the productivity and competitiveness of our economy and the knowledge we have to help make informed decisions as a society. Science provides that knowledge and informs those decisions. The science system contributes know-how for economic growth, helps to identify and manage risks in the natural world, and provides skilled researchers and workers to support an innovation economy. MBIE aims to increase the economic contribution of the skills, science and innovation systems.

2.2 Objectives of the plan

The principal objective of this strategic plan is to:

> Encourage and enable better engagement with science and technology across all sectors of New Zealand.

This means:

- a more scientifically and technologically engaged public and a more publically engaged science sector;
- more science and technology competent learners choosing STEM-related career pathways.

Outcome 1: a more scientifically and technologically engaged public and a more publically engaged science sector

We will know we're making progress on this when:

- a greater proportion of New Zealanders across all sectors of society are engaged with, and value, science and technology
- there is more in-depth media reporting on science and technology based on robust scientific evidence
- there are increased opportunities for the public to learn and be involved in scientific research and uptake continues to grow across all tiers of society
- there are more opportunities for the public and the science sector to engage in discussion about societal use and limits of new technology and applications for existing technology
- publically funded research responds to the needs of New Zealanders and recognises the diverse needs and issues of communities.

Outcome 2: more science and technology competent learners choosing STEM-related career pathways

We will know we're making progress on this when:

- we achieve greater student demand for STEM courses and qualifications at all levels of the qualifications framework (1-10)
- we have developed greater teacher confidence in teaching for STM outcomes
- teachers have improved access to the resources they need to teach STM subjects and links between the STM curriculum and career pathways are clarified.

Outcome 3: a more skilled workforce and more responsive science and technology sectors

In the longer term, we expect that progress towards outcomes one and two will contribute to New Zealand's economic growth and social and environmental wellbeing through:

- a greater number of New Zealanders with the skills needed to support creativity, innovation and knowledge uptake and use
- publically funded science and technology which responds to the needs of New Zealanders
- New Zealanders make more informed decisions on issues of importance to 21st century life.

2.3 The State of Play – what we know and what we don't know

How scientifically and technologically engaged are the public and how publically engaged is the science sector?

There is no current comprehensive measure of public engagement in science or technology or adult STEM literacy

It is difficult to measure public engagement in science and technology and there is no internationally accepted metric to capture it. The best New Zealand evidence is a survey of public attitudes to science in New Zealand[17]. The survey identified that about half of New Zealanders were actively interested in science and the other half did not recognise the relevance of science in their daily lives[18] (44%) or were disengaged in science (9%). Similar surveys have been done in other countries. However it is difficult to draw comparisons given differences in the questions[19]. The Government has not surveyed public attitudes to technology outside this survey.

Relative to comparable countries, a relatively high proportion of New Zealand adults have a secondary or tertiary qualification[20]. There is no data on the proportion of these qualifications that are in STEM subjects. From 2016 New Zealand will assess adult competencies in reading, mathematics and problem solving in technology-rich environments through the Programme for the International Assessment of Adult Competencies.

There is limited data on the level and effectiveness of the engagement of the science sector and science and technology communicators with the public

There is increasing recognition today of the broader social responsibility of scientists to engage with the wider public in meaningful ways[21]. It is difficult to track and measure this engagement, however, in part because it can take place in a great variety of venues and with various goals in mind. Two main ways that scientists fulfil public engagement is by conveying knowledge to governments to ensure science-informed policy and decision making, and through more direct engagement with the public.

Despite the clear objectives, it is still difficult to measure the impact of these types of engagement. In 2013/14 the Government will invest $1.36b[22] to support science and innovation in New Zealand. A proportion of that expenditure is expected to be spent on by universities and science organisations on making research more accessible to end-users through communication, public outreach and public education, but it is difficult to estimate the proportion. Other government investment in these organisations may also be spent on communication, public engagement and education.

There are also many local government and private sector organisations, such as industry training providers, zoos, museums, science centres, charities and businesses that engage with the public on science and technology for education, cultural and marketing reasons. The Government also invests $167m in public broadcasting services and funding museums[23].

It is inherently difficult to evaluate the impact of public engagement activities[24].

Since the Science Media Centre was established in 2008, 'science' in the media has increased by 75%[25].

Use of evidence in policy development

The State Services Commission has recently undertaken a review of government agencies to identify places where the role of departmental science advisors could lift internal capabilities to take up research and new knowledge. A network of advisors chaired by the Prime Minister's Chief Science Advisor will grow in responsibility as additional Science Advisors are appointed. These changes are expected to help strengthen the channels of communication with the science sector and progress will be monitored as departmental science advisor positions are filled. The network is required to report on progress to the State Services Commissioner in12 months.

How competent are STEM learners and how many are choosing STEM-related career pathways?

There are STEM skills shortages

There are currently skills shortages for many kinds of scientists, engineers, technologists, health and ICT professionals[26]. Demand for workers in many STEM-related occupations is expected to grow due to a variety of factors[27]. In addition, many jobs not directly STEM-related require STEM competencies. Internationally it is estimated that up to 75% of high-growth jobs require STEM skills and competencies[28].

The number of NZ graduates is growing, but international demand is growing faster

The number of domestic students completing bachelor degrees across all fields of study has increased from 19,596 in 2005 to 25,350 in 2012. For example, in the natural and physical sciences the increase has been from 1,937 in 2005 to 2,649 in 2012. The numbers of degree-level engineering training places funded by the government has recently increased. The industry training providers are facing difficulties in growing engineering at technician and technology qualification levels[29]. More than 40% of enrolments at bachelor's level and above are in health; natural and physical sciences; engineering and related technologies, IT, and architecture and building[30]. Girls and women are under-represented in studying and working in STEM, apart from the health and biological sciences[31].

There is a global demand for those with STEM qualifications. Those who gain STEM qualifications required for job-shortage areas can be lost from New Zealand to the global job market or other careers. MBIE estimates that fewer than half of New Zealand graduates work in

the same field in which they studied. Many New Zealand graduates with the skills matched to the New Zealand market go overseas to work. Much of this skills loss is replaced by highly skilled immigrants. However, it is expected to become increasingly difficult to attract these immigrants as wages rise in increasingly knowledge-intensive Asian economies.

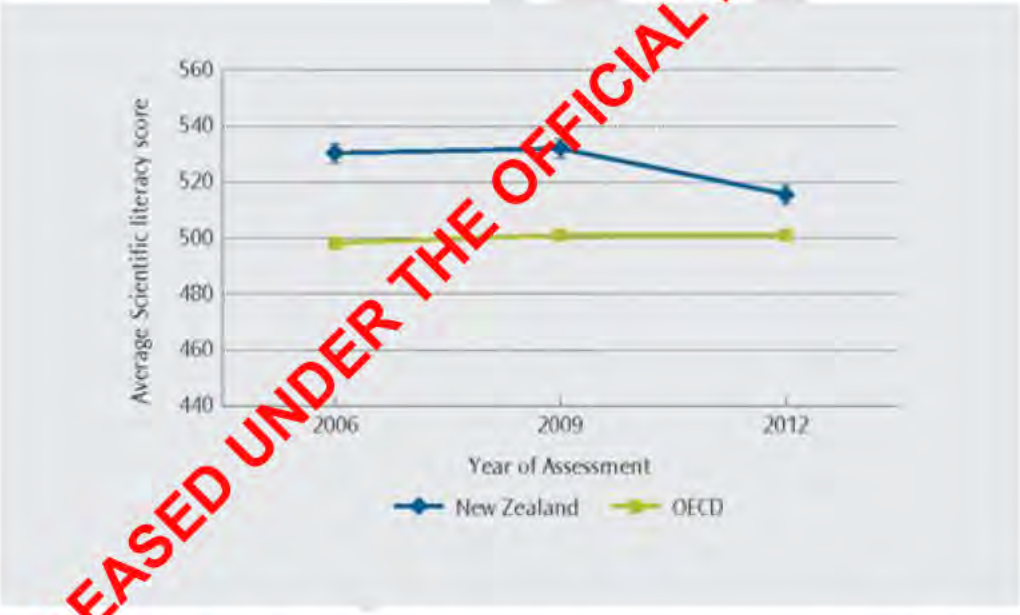
New Zealand school student performance in science has declined

New Zealand has a highly respected education system. The World Economic Forum's Global Competitiveness Index for 2013[32] noted that New Zealanders spend the longest time in education from primary to tertiary, at 19.67 years and ranked New Zealand seventh for overall education indicators out of 142 countries.

Despite this, there is a gradual decline in the proportion of students enrolled in science-related subjects in years 11 to 13[33].

New Zealand students' performance in science has also declined, and the decline is more marked in the later years of schooling. The average performance of New Zealand year 5 students for science in 2010/11 was significantly lower than in 2002/3[34] and there has been no significant change in performance for year 9 students since 1994/5. The performance of New Zealand students at age 15 years (most students are in year 10 at this age) in science remained relatively stable up to 2009 and declined between 2009 and 2012[35].

Figure One: Graph showing changes in the average science literacy score for New Zealand students at 15 years between 2006 and 2012 compared to the OECD average[36]



The National Monitoring Study of Student Achievement (NMSSA) and the Programme for International Student Assessment (PISA) results also show growing inequity in student performance in science, particularly for Māori students and Pasifika students.

There is limited data on school student performance in technology

There is limited data on student performance in technology because it is not measured by PISA or TIMMS, and NMSSA is yet to assess it. [MoE to update]

What is causing the student performance decline?

Research suggests that student achievement in science is declining in part because science teachers are not confident in their ability to teach science, particularly to diverse groups. Teachers do not have access to appropriate resources, and students lack confidence in their ability to succeed in STE subjects and lack support for deciding on senior secondary school subjects[37].

2.4 The challenges and how we can best address them

The challenges are:

- Increasing the engagement of New Zealanders, across all sectors, with science and technology and increasing the effectiveness of the science sector's engagement with the public
- Increasing the numbers of learners with STE competencies to meet the needs of their everyday lives and the 21st century labour market.

To address these challenges we need to:

- *Build a nationally supportive environment for public engagement in science and technology and, equally, for the science sector's engagement with the public.*

  This needs to focus on identifying, encouraging and supporting the most effective ways for the science sector and science and technology communicators (such as the media, museums and event organisers) to engage with the public, particularly young New Zealanders and those New Zealanders that are disengaged or do not see the relevance of science in their daily lives. The environment needs to encourage improved dialogue. There is already significant activity in these areas so encouraging good practice and greater coordination could have benefits.

- *Improve teacher confidence through high quality science and technology teacher education, support quality teaching, learning and assessment in science and technology;*
- *Develop science and technology-specific curriculum materials that build towards future-oriented approaches and support teachers to use them; and*
- *Improve linkages between STM educators, scientists, businesses, technologists and learners and the community.*

  These are the key levers that national and international research on effective teaching and learning in science and technology[38] have identified as critical for improving student engagement and achievement. A comprehensive and coherent programme of improvement that drives these levers and utilises all of the existing resources and expertise across the science and technology education systems is needed to meet the challenge of increasing the STEM competencies of New Zealand's young people.

PART 3 Strategic Action Areas and Priority Actions

Some action has been taken towards encouraging and enabling engagement by New Zealanders with science and technology. The government's current activities are described in Annex 2. However, to deliver on the objectives and outcomes in this plan a step change is needed.

In particular, further support is needed to help develop teacher confidence and science competencies at the primary levels through initial teacher training; and at all levels through

continuing professional learning and development, and better links between practicing scientists (including post-graduate trainees and private sector scientists) and schools.

Continued support is also needed to encourage effective ways for the science sector and other science and technology communicators to engage with the public, including through two-way dialogue; and further support is needed for good practice, greater impact and improved coordination.

The following section sets out 3 Strategic Action Areas (SAAs), each with a set of priority actions to be carried out over the next three years, but maintaining a view on the 10-year horizon, commensurate with the National Science Challenges.

In addition to these Strategic Action Areas at the heart of this plan is a Priority Action that spans all three SAAs: the Participatory Science Platform. This platform (described in section 3.4) is especially designed to simultaneously:

- Work with the education sector to make it easier to bring "real-world" science into the classroom by connecting teachers with practicing contemporary scientists (SAA1)
- Enable and foster the public's understanding of and engagement in real-world science through research that is relevant to local communities (SAA2)
- Offer opportunities for practicing scientists to become better engaged with the public by contributing both to science education and to filling knowledge gaps that are locally relevant and scientifically interesting (SAA3).

3.1 Strategic Action Area 1: Further enhancing the role of the Education Sector

The principal goal of Strategic Action Area 1 is to support all young New Zealanders to be resilient learners with future-proofed skills to understand, assess and apply rapidly changing science and technology knowledge to their everyday lives. This goal will contribute to building creativity, innovation and increased critical science literacy. Strategic Action Area 1 will include a focus on quality teaching and learning and providing additional opportunities to enhance competencies, confidence and dispositions that grow scientific knowledge, curiosity and creativity in students in partnership with schools and kura, families, whanau, iwi and the business and science communities.

The activities in Strategic Action Area 1 are focused on five key intervention sites: early Childhood Education, primary level education; secondary level education; the transition to further study/training or employment; and science leadership.

A growing body of literature signals the case for integrating quality teaching practices with technology to change knowledge Actions will explicitly focus on enabling a future-oriented science and technology education system. Integrative thinking for improving science and technology teaching and learning, skills and dispositions for innovation, and changes to pedagogical practice as e-learning and ICT evolves will be central. This will include how the focus of science education should differ at the different levels of schooling.

Actions include:

1. *Improve initial teacher education for increased science teaching competencies and competence*. Primary teachers are necessarily generalists. New research has shown that primary education is an important window of opportunity for imparting foundation curiosity and learning behaviours for learners' future attitudes and practices toward science and technology. To maximise this opportunity new primary teachers need the confidence and content knowledge to sustain student engagement and progress.

   Activities include:

- The Ministry of Education will work with initial teacher education providers, qualification accreditation bodies and relevant professional bodies to identify ways to lift the level of science content in initial teacher education. This could form a component of under-graduate qualifications for primary education, and would be targeted to lift the confidence of graduating teachers to teach science (teachers currently report limited confidence, particularly at years 7-8).

2. *Improve the quality and relevance of continuing professional learning and development opportunities for teachers in science and technology.*

The Government spends more than $70 million every year on professional learning and development to support the development of a highly capable profession, and a professional learning and development system that builds the skills of teachers and education leaders, which in turn delivers measurable gains for students in science/pūtaiao, technology/hangarau and mathematics/pāngarau.

In 2014 approximately $5,663,709.00 was appropriated to science and technology PLD. This figure does not include the science and technology PLD which is inside other contracts, and that schools can apply for on the basis of need.

The Minister of Education has appointed an Advisory Group with representatives from across the education sector to provide advice on the design of future professional learning and development across the compulsory schooling sector. The group will provide advice on what improvements should be made to the targeting of PLD to achieve a system-wide lift in student achievement, and provide advice on how changes could be implemented to achieve the maximum impact.

Activities:

- Provide teachers of science in years 1 to 10 with opportunities to work within research organisations and develop leadership skills to enhance the teaching of science within school communities
- Promote the Science/Biotechnology Learning Hubs as a high-quality online repository of New Zealand science for teachers and students
- Create a Science Skills in Education Initiative to support schools and teachers to build confidence and access resources to develop rich, contextualised science programmes that are exciting for students. The initiative will be developed with education and industry stakeholders to create a network between local industry, local and national government and schools to assist teachers to continue their science education with providers who have a proven record of excellence in science teaching. Examples include access to courses for primary teachers with a focus on developing science skills and knowledge that reflect science/pūtaiao in the national curriculum, and expanding the availability of the Sir Paul Callaghan Academy initiative. This initiative focuses on teacher learning, and will explore links to the Science in Industry Programme as appropriate.

- Create a Science in Industry Programme to promote science and technology in industry and business settings as exciting and valuable career pathways for students. The programme will offer opportunities for teachers to connect and be involved with local industries and businesses during school holidays, to reflect on the practical application of science and technology in their school-based

programmes. This initiative focuses on building the currency of programmes, and will explore links to the Science Skills in Education initiative as appropriate.

3. *Build and maintain meaningful linkages between science and technology educators and learners, and practicing scientists and technologists, both in the classroom and through opportunities that engage the wider community:* Partnerships with universities, CRIs, private bodies, science organisations (such as museums, science centres, zoos, aquaria, observatories) and secondary-tertiary programmes that enable participants to experience tertiary-level educational activities, are all key for learning outside the classroom. These learning experiences outside the classroom need to be integrated meaningfully within teaching and learning programmes.

   Activities include:

   - Build and strengthen links between teachers, learners and practising scientists by promoting quality Learning Experiences Outside The Classroom.
   - Explore equitable funding models to enable schools / kura to meet the costs of students attending Learning Experiences Outside The Classroom.
   - Identify the assessment standards on the National Qualifications Framework (levels 2 and 3) that will;
     - improve students access to experiential applied STEM learning opportunities
     - enable students to make informed choices about progression to higher level STEM related pathways
     - improve the visibility of STEM capabilities within assessment standards
   - Provide a Participatory Science Platform (described below) that engages schools, community-based groups and organisations and practicing researchers in questions that are scientifically rigorous, locally relevant and pedagogically innovative. The platform includes central coordinator roles that will oversee the platform and be a conduit between learning environments and scientists.

4. *The Ministry will work alongside sector partners to review and update the provision of ICT including its positioning within the framework of the New Zealand Curriculum. It is intended this will result in additional guidance and support materials exemplifying ICT provision across primary and secondary years and will complement the National Certificate of Educational Achievement (NCEA) review and maintenance programme.*

3.2 Strategic Action Area 2: Public engaging with science

The goal of this Strategic Action Area is to build a nationally supportive environment for public engagement in science and technology. In addition, the Action Area is also designed to increase the number of such learners with an interest in STEM-related career pathways. This action area recognises the changing demographic of New Zealand including the increasing iwi and hapū asset base and the partnership model of service delivery. It operates with Strategic Action Area 3 to encourage greater dialogue between the science sector and the public by helping move toward 'a more scientifically engaged public' and 'a more publically engaged science sector'.

In the immediate term, the objective is to enhance the quality, breadth and depth of science communication to the public by the media, scientists, and organisers of national science and technology public events, support youth into science and technology based careers and build greater connectivity across sectors. In the longer-term, Strategic Action Area 2 recognises that the true culture change necessary to encourage and enable public engagement in science must start with young learners, their teachers, their families/whanāu and their communities.

1. *Support quality science journalism and blogging in the multi-platform media:* Print, television and online media (including socially networked media and blogging) are powerful tools for engagement with the public. This priority action will continue to harness the positive power of the media to help make science and the complexities of risk and scientific uncertainty more accessible.

   Activities include:

   - Enhance the role and reach of the Science Media Centre to support more training and outreach to science journalists to encourage responsible and insightful science news reporting and long-form analysis that is relevant to the New Zealand public.

2. *Support quality national initiatives on science and technology that target traditionally hard-to-reach audiences:* There is a growing recognition internationally that efforts to engage the public in science and technology find their greatest success with people who are engaged in science. The challenge is to reach and inspire a broader base of New Zealanders through initiatives that bring science and technology to groups that are generally considered harder to reach. This action will support such initiatives with a broad reach, extending beyond a local area.

   Action:

   - Establish a contestable fund for nationally delivered initiatives that deliver on the plan and target hard to reach groups of the public and could not proceed without government support.

3. *Support youth into science and technology-based careers*: Continue to develop more responsive educational pathways and raise awareness about the impacts of student subject choices, including on entrepreneurial thinking in the science and innovation sector. The relevance of science and technology learning to future careers options needs to be made clearer at an earlier stage for learners and potential careers should be highlighted.

   Activities include:

   - work with Careers NZ to explore and develop ways to raise awareness of science and technology careers on the Careers NZ website.
   - continue work to develop and promote the uptake of information provision for learners about science careers
   - continue to support talented school students through young achievers and travel awards
   - explore more strategic targeting of the Futureintech programme, and other potential changes to increase its impact
   - review and evaluate the pilot of the Science Education Leadership and Coordination role for merit to expand
   - utilise Vocational Pathways to support schools to design curriculum programmes that contextualise learning in ways that better meet learners' needs and interests, including science and technology education
   - consider how to strengthen science literacy in senior secondary schooling particularly at Year 11
   - consider the future of the STEM feature in the occupational outlook

4. *Build and maintain meaningful linkages between science and technology-led businesses, science and technology educators and learners, and practicing scientists and technologists:* Improving connections between science and technology-led businesses and learners will give more learners real world understanding of potential STEM career pathways. It will enable more science and technology-led businesses to promote STEM careers and build early connections with future employees and deliver growth and economic outcomes.

    - establish mechanisms to connect business, local government, educators and the science community at a regional, industry or sector level.

5. Support *parents and whānau to increase their engagement with science*: The development of parental/whānau and community involvement acknowledges and builds on the importance of parents and families/whānau and local communities as young learners' first mentors, while also providing an opportunity to encourage parents' engagement with science through community collaborative research opportunities that bring together practising scientists with schools and other community organisations on real-world questions.

    Action:

    - Provide a Participatory Science Platform (described below). The platform will offer schools and their communities opportunities to participate in scientific research in projects with broad appeal, scientific value and pedagogical rigour that resonate with the community.

6. Build greater connectivity with museums, zoos and science centres: Non-traditional learning environments, such as those provided by museums, zoos and science centres, can play an important part in encouraging STEM competencies and innovations. Reaching millions of New Zealanders each year, museums and other science organisations facilitate engagement and lifelong learning and are ideally placed as community spaces or forums.

    Activities include:

    - Work with organisations such as museums, zoos and science centres to agree their role in delivering on the plan.

7. *Build the evidence base on public attitudes to, and engagement with, science and technology. Improved evidence on public attitudes to, and engagement with science and technology, will assist in targeting future actions. It will form part of the monitoring and evaluation framework for the plan.*

    Action:

    Regularly survey public attitudes to, and engagement with, science and technology.

3.3 Strategic Action Area 3: Science engaging with the public

Strategic Action Area 3 complements Strategic Action Area 2 because there cannot be a scientifically engaged public without there also being a publically engaged science sector. This Strategic Action Area recognises the important role that the science sector plays in ensuring the public relevance of research, whether through saleable innovations or policy-relevant results. Publically funded science organisations and scientists have a social responsibility to share some level of knowledge where it's applicable. We also look to science for useful new technologies and evidence-based guidance on society's most pressing issues.

1. Ensure that publically funded scientists continue to employ leading edge knowledge and international best practices to engage relevant public(s) in identifying priority research questions and usefully disseminating results.

   Activities include:

   - Public research funding bodies will review and update the knowledge translation expectations attached to direct purchase /grants for research and contracts, and assess the current state of publically-relevant knowledge transfer and end-user engagement practice among funding recipients, including with Iwi and Maori organisations. Results of this exercise can be used to inform training material for grantees and future decisions about the research funding
   - Build on the success of the public engagement process used to identify the National Science Challenges by considering the adoption of a similar approach to engaging the public in the implementation phase of the National Science Challenges
   - Royal Society of New Zealand and the Prime Minister's Chief Science Advisor will work with the scientific community to develop a Code of Practice for Scientists that enshrines their public responsibilities. A recent model of such a commitment is the Japanese Council of Science's recently updated Code of Conduct of Scientists, which outlines not only the responsible conduct of research but also the social responsibility of science organisations and scientists to engage with the public and policy makers based on their expert knowledge.
   - Continue to implement recommendations of the Prime Minister's Science Advisor on the use of science-based evidence in policy formation, by creating opportunities, through new Departmental Science Advisors, for the science community to engage with government and share relevant results with policy makers.

2. *Ensure that emerging and established scientists and technology researchers have the basic communication skills to make their research accessible to relevant audiences beyond their peer community.*

   Action:

   - Work with the tertiary sector, including ITPs and ITOs, to identify ways to ensure that all emerging and established science and technology researchers have access to training that supports engagement and the dissemination of their knowledge to non-academic audiences.
   - Continue to ensure that scientists' excellence is acknowledged and showcased through the Prime Minister's Science Awards.

3. *Increase the prominence of the work of Māori researchers in science/pūtao and of all researchers engaged in* mātauranga Māori.

   Activity:

   - Engage with researchers who are Māori, iwi and Māori organisations about their mātauranga Māori and science knowledge and science projects to build connectivity.

4. *Support scientists to contribute meaningfully to schools and communities, while advancing their scientific output, by enabling their involvement in participatory research.*

   Activity:

   - Provide a Participatory Science Platform (described below). The platform will match scientists and members of schools or community organisations seeking to take part in community-initiated and scientist-initiated research.

3.4 Integrating Action: The Participatory Science Platform

While the three SAAs described above each target specific sectoral goals, they are nonetheless interconnected. A unique feature at the heart of this strategic plan is an integrating activity that simultaneously addresses important objectives in all three SAAs. The Participatory Science Platform has the potential to: offer inspiring and relevant learning opportunities for students and teachers; engage learners and participants beyond the school community to reach parents, whanau and wider communities; and offer researchers the opportunity to become involved in locally relevant lines of enquiry, where data can be enriched by the local knowledge and contribution of citizens.

The Participatory Science platform builds on traditional concepts in citizen science and enhances these through collaborative approaches more common to community-based participatory research. Participatory Science is a method of undertaking scientific research where volunteers can be meaningfully involved in research in collaboration with practicing scientists (including post-graduate trainees and private sector scientists) and builds on international models of engagement.

The Participatory Science platform is built on four core components and incorporates Matauranga Māori:

1. A process that seeks ideas for participatory science projects from both the community (including schools, museums and other organisations, iwi authority or community associations) and from practicing researchers (from post-graduate trainees to principal investigators in both the public and private sectors);
2. A managed process for evaluating these ideas for both pedagogical potential (in the case of schools) and scientific quality, and for ensuring their practicality and relevance to the participating partners (science sector and community-based);
3. A web-based match-making process between interested community-based partners and practicing researchers; and
4. A resource for teachers and other community or learning leaders to assist in developing their projects to robust standards.

The goal is to involve schools and/or community-based organisations such as museums and associations in projects with broad appeal, having both scientific value, pedagogical rigour, and that resonate with the community. In addition, we are testing several ideas for projects of national significance that would integrate with the National Science Challenges and be national in reach.

The website will serve as a match-making tool between scientists and potential community-based partners seeking to take part in a research project by offering a platform for community-initiated and scientist-initiated research.

A multi-sectoral management and review panel will be established to maintain quality control over the programme and advise on any research ethics requirements.

All projects must have an institutional home which will provide a coordination role. This could be a school, museum, zoo, science centre, iwi office or research institute, university or other tertiary institution.

To enable more sophisticated projects, a limited number of one-time seed grants will be made available to help foster a meaningful level of community involvement. The seed-grants will part-fund practicing researchers and community/school groups to plan together the research question, data collection, analysis and knowledge translation strategy for the project. In addition, eligible costs could include research tools or consumables that would not otherwise be accessible to community partners.

The projects will be offered as opportunities for community based partners to participate in scientific research as a way to enhance their local input, their science knowledge and their interest, and (in the case of schools) to strengthen learning programmes through stronger links to relevant learning environments and expertise.

Once matches are made between community based partners and scientists, these partners would self-direct their involvement in carrying out the research according to an agreed plan and approach.

A multi-media campaign will accompany the launch of programmes and a dedicated website/social media site will provide a sustained channel of communication for ideas that continue to emerge. It will build on the momentum created by the *Great New Zealand Science Project* and leverages the legacy of that project, including its Facebook page.

3.5 Other government initiatives support the plan

Other government initiatives will contribute to delivering on this plan such as.

- Investing in Educational Success – Teaching and Leadership career pathways initiative which targets raising achievement through quality teaching and professional leadership offers an expanding environment in support of the principal objective of this plan.
- The New Zealand Qualifications review of qualifications – mandatory reviews of science qualifications and the review of tertiary teaching qualifications are taking place during 2014.
- Tertiary Education Strategy (TES) - The two most relevant strategic priorities in the TES for this plan are: Priority 1, delivering skills for industry, including in areas of new and emerging shortage such as science and technology; and Priority 5, strengthening research-based institutions. The TES emphasises the importance of tertiary institutions being more outwardly focussed, in particular, connecting learning to employment outcomes and encouraging providers to be more connected to industries and communities.
- The State Service's Commission's efforts to include action for better use of evidence in public policy formation. This is being operationalised through the creation of a number of Departmental Science Advisor roles and the creation of a network of these advisors chaired by the Prime Minister's Chief Science Advisor. This plan recognises the role of scientists to better connect with the public service through the DSA network and other opportunities to bring evidence into policy formation
- The Office of the Prime Minister's Chief Science Advisor was established, in part, to address the role of science in society. Positioned at the nexus of the science community, government, and the public, a central focus of the Office is to help establish better communication of concepts in science and research to the public and to

government. This plan recognises the uniqueness of the PMCSA model internationally and can leverage the channel of public communication that the Office provides.

- MBIE's Vision Mātauranga policy states that unlocking the science and innovation potential of Māori knowledge, people and resources will benefit New Zealand. The four themes of the Vision Mātauranga policy are:
    - Indigenous innovation: contributing to economic growth through distinctive science and innovation
    - Taiao/environment: achieving environmental sustainability through iwi and hapū relationships with land and sea
    - Hauora/health: improving health and social wellbeing
    - Mātauranga: exploring indigenous knowledge and science and innovation

  For this reason the Vision Mātauranga policy is embedded across all priority investment areas, and as such forms a core component of the Science in Society approach to Māori.

PART 4 Implementing and evaluating the plan

Addressing the challenges described in the plan are longer term issues that will require a commitment to sustained change. It will also require us to learn, modify as we go and continue engaging with stakeholders.

4.1 Implementation approach

The government has asked the Science in Society Reference Group to reconvene in 2015 to review progress and advise on any modifications to the priority actions. The Ministry of Business and Innovation and the Ministry of Education together with the PM's CSA will coordinate implementation of the plan by government agencies, iwi and other sectors including the education, science, business and museum sectors. They will also lead a process of engagement with the public on the plan and the actions in it.

Central to the terms of reference of the Prime Minister's Chief Science Advisor is to support an improved and productive relationship between science and society. As such, the PMCSA and the network of Departmental Science Advisors will continue to be active in implementation of the plan.

4.2 Timeframe

While the challenges are long-term, the plan sets out a direction for the next ten years and actions for the next three years from 2014 to 2017. The actions may be modified and enhanced as we learn more over the life of the plan.

Some actions are already being progressed as they continue or enhance effective existing actions. Enhancing the role of the Science Media Centre and the Ministry of Education's pilot of a strategic leadership and coordination role for better connecting schools and the science sector are examples of these actions.

The plan also includes actions that can be implemented in the short to medium term. For example, the participatory science platform and the contestable fund for nationally delivered one-off events can be developed in 2014/15 for implementation in 2015/16.

Finally, some of the proposed action areas for the education sector require a longer term (Year 1-6) approach. This will ensure that there is sufficient time to address changes around, for example, initial teacher education, and linking classrooms to the professional science

community. These actions will help inspire and provide authentic learning opportunities of relevance and interest to students.

4.3 Monitoring and Evaluation Framework

A monitoring and evaluation programme will be developed to measure baselines and track progress in delivering on this plan and inform further development.

Annex 1: Process for developing this plan

This plan was developed by the Ministry of Business, Innovation and Employment, the Ministry of Education and the office of the Prime Minister's Chief Science Advisor on behalf of the Government.

A Science in Society Reference Group of experts provided advice to assist the government to develop this plan. The members of the Group are:

Professor Sir Peter Gluckman (Chair)	Professor Sir Peter Gluckman is the Prime Minister's Chief Science Advisor. He was the founding Director of the Liggins Institute and is one of New Zealand's best-known scientists. He is internationally respected for his work promoting the use of evidence in policy formation and the translation of scientific knowledge into better social, economic, and environmental outcomes. Professor Sir Peter is a Fellow of The Royal Society (London), the Commonwealth's most prestigious scientific organisation. He is the only New Zealander elected to the Institute of Medicine of the National Academies of Science (USA) and the Academy of Medical Sciences of Great Britain. In 2009 he became a Knight of the New Zealand Order of Merit for services to medicine. In 2001 he received New Zealand's top science award, the Rutherford Medal.
Professor Jim Metson (Deputy Chair)	Professor Jim Metson is Chief Science Advisor to the Ministry of Business, Innovation and Employment. He has a PhD in Chemistry from Victoria University of Wellington and is Deputy Dean of Science at the University of Auckland, Professor in its School of Chemical Sciences, and Associate Director of the University's Light Metals Research Centre. He has a background in building science capability, and has led the formation of several major interdisciplinary research centres at the University.
Professor Alister Jones	Professor Alister Jones is Deputy Vice-Chancellor of the University of Waikato. He was Dean of Education and Research Professor and Director of the Wilf Malcolm Institute of Educational Research at the Faculty of Education. He has managed and directed research projects that have informed policy, curriculum, science and technology education and teacher development in New Zealand and internationally. He was awarded the New Zealand Science and Technology Medal. He is Co-Director of the Science Learning Hubs and co-chairs an APEC working group on science and mathematics education.
Jacquie Bay	Jacquie Bay is the founding Director of LENScience, an innovative science education programme within the Liggins Institute. She co-developed the award winning LENScience Connect learning platform for science education.
Hikitia Ropata	Hikitia Ropata is the General Manager Strategic Development at Careers NZ. She is also a member of the Export Industry Skills Analysis Advisory Group. She has worked across both social and economic policy and delivery spaces. Her specific interest is in getting more New Zealanders interested and participating in science and technology careers, particularly Māori and Pasifika. She is of Ngāti Toa, Ngāti Raukawa, Te Ati Awa, Ngāti Porou descent.
Peter Griffin	Peter Griffin is the founding manager of the Science Media Centre and the founder and editor of Sciblogs. He was Technology Editor of the New Zealand Herald, technology columnist for the Herald on Sunday and a commentator for TVNZ, Radio New Zealand and Radio Live. In 2012 Peter was a Fulbright-Harkness Fellow undertaking research in the US looking at centres of excellence in public interest journalism.
Richard Meylan	Richard Meylan is Senior Manager Public Engagement and Education at the Royal Society of New Zealand and formerly was Principal Adviser to the New Zealand Ministry of Research, Science and Technology. He is a former teacher and in 2011 spent nine months on a sabbatical to the International Council for Science in Paris.

Lee Parkinson	Lee Parkinson is a communications consultant. A Chartered Marketer and Fellow of the Chartered Institute of Marketing, he was recently Managing Partner of Ikon Communications. Lee attended the Transit of Venus forum and was consulted in the development of communications approach for Great New Zealand Science Project.
Dr Steven Sexton	Dr Steven Sexton is President of the New Zealand Association of Science Educators. He is a senior lecturer in Science Education at the College of Education at the University of Otago. He was a primary school teacher.
Dr Jan Giffney	Dr Jan Giffney is Head of Science at St Cuthbert's College, Auckland. She was honoured with a prestigious professional award – the Independent Schools of New Zealand Excellence in Teaching Award for Exceptional Professional Performance for Years 11–13. She is also an experienced chemistry teacher with a long history of involvement in the NZ Chemistry Olympiad programme.
Ally Bull	Ally Bull leads the science education team at New Zealand Council for Educational Research. She has expertise in research on science education and is co-convenor of the NZ Association for Research Education Science education Special Interest Group.
Angela Christie	Angela Christie is Director – Schools at the Institution of Professional Engineers of NZ. She is responsible for the development and implementation of the Futureintech Project – a government-funded careers promotion initiative. She also manages the IPENZ school programmes.
Evan Brenton-Rule	Evan Brenton-Rule is winner of the 2013 Eureka Award for Young Science Orators for his presentation about a solution for the threat posed by invasive species in New Zealand. Evan is studying towards law and science degrees at Victoria University of Wellington.

The Reference Group, the National Science Challenges Panel, Business New Zealand; Science New Zealand; the New Zealand Association of Scientists; municipal museums; the Royal Society of New Zealand, the Chambers of Commerce, Callaghan Innovation, the Secondary School Principals Association; New Zealand Principals Federation; the Post-Primary Teachers Association; the New Zealand Education Institute; the leadership of Universities, Polytechnics and Wānanga; the Tertiary Education Union; the New Zealand Union of Students Association; and stakeholders from Society of Māori Astronomy and Research Traditions and Ngā Pae o te Māramatanga provided feedback on a draft of the plan.

Annex 2: Description of initiatives [To be completed]

KEY: Existing action continuing | Changed existing action | New project

Strategic Action Area	Goal	Action	Status	Lead agency	Other agencies	Comment
Education Sector	Improve initial teacher education	Work with initial teacher education providers, qualification accreditation bodies and relevant professional bodies to identify ways to lift the level of science content in initial teacher education.		MoE		This could form a component of under-graduate qualifications for primary education, and would be targeted to lift the confidence of graduating teachers to teach science (teachers currently report limited confidence, particularly at years 7-8).
	Improve the quality and relevance of continuing professional learning and development opportunities for teachers in science and technology	The Ministry of Education provides professional learning development (PLD) in both English-medium and Māori-medium to build teacher capability and confidence to deliver learning programmes in science/pūtaiao, technology/hangarau and mathematics/pāngarau.		MoE		
		Provide primary and secondary school teachers with opportunities to work within research organisations and develop leadership skills to enhance the teaching of science within school communities.		MBIE		Reframe the teacher fellowship programme to include a 'school science leadership' component with a focus on science teaching and leadership competencies
		Promote the Science/Biotechnology Learning Hubs (provides an online repository of New Zealand science for use by teachers and other New Zealanders)		MBIE		Promote the Science/Biotechnology Learning Hubs as a high-quality online repository of New Zealand science for teachers and students
		Create a Science Skills in Education Initiative to support schools and teachers to build confidence and access resources to develop rich, contextualised science programmes that are exciting for students.		MoE		The initiative will be developed with education and industry stakeholders to create a network between local industry, local and national government and schools to assist teachers to continue their science education with providers who have a proven record of excellence in science teaching. Examples include access to courses for primary teachers with a focus on developing science skills and knowledge that reflect science/pūtaiao in the national curriculum, and expanding the availability of the Sir Paul Callaghan Academy initiative. This initiative focuses on teacher learning, and will explore links to the Science in Industry Programme as appropriate.
		Create a Science in Industry programme to promote science and technology in industry and business settings as exciting and valuable career pathways for students. The programme will offer opportunities for teachers to connect and be involved with local industries and businesses during the school holidays, to reflect on the practical application of science and technology in their school-based programmes.				This initiative focuses on building the currency of programmes, and will explore links to the Science Skills in Education initiative as appropriate. Participants would be supported to reflect on the practical application of science in industry for their lessons plans, upscale Learning and Change Networks for science, and explore the development of virtual learning networks for science teachers on the Network 4 Learning portal. This will enable groups of schools to connect with the broader community whilst focussing on raising

		,				science literacy
	Develop science and technology curriculum materials and support teachers to use them	The New Zealand Curriculum (NZC) and Te Marautanga o Aotearoa address STM skills development and building a scientifically and technologically engaged population more generally.		MoE		The NZC identifies five key competencies which are to be developed through the opportunities afforded students in the eight learning areas of the curriculum. Science literacy is valued as an outcome at the heart of the science learning part of the NZC. It is supported by students developing the key competencies as well as by other resources in other education and community contexts
		The Matakōkiri Project supports students to engage with science by linking science/pūtaiao to Māori language, culture and identity through students' local t kanga, whakapapa and stories.		Te Taumata o Ngāti Whakaue Iko Ake Trust		The project is an iwitanga-based science programme run by Te Taumata o Ngāti Whakaue Iko Ake Trust in their rohe for their students, whānau, teachers and schools.
		Establish Learning and Change Networks with a dedicated focus on student achievement in science.		MoE		These are communities of practice that provide an environment for the building of sustainable partnerships between families, whānau, iwi schools and kura to listen to student voice about what matters most for their learning and achievement. Together these communities co-construct responses to a learning challenge to enable accelerated progress towards equitable outcomes for priority groups and student achievement. In 2014 new networks will be established with a dedicated focus on student achievement in science.
		A range of online and print publications to support quality teaching, learning and assessment		MoE		These focus on how to deliver personalised learning, develop authentic learning experiences for students and build partnerships between schools, teachers, students, families and whānau and communities to ensure diversity of STEM education and success for all learners.
	Build and maintain meaningful linkages between science and technology educators and learners, and practicing scientists	Build and strengthen links between teachers, learners and practising scientists by promoting quality Learning Experiences Outside the Classroom		MoE		
		Explore equitable funding models to enable schools / kura to meet the costs of students attending Learning Experiences Outside The Classroom.		MOE		
		Identify the assessment standards on the National Qualifications Framework (levels 2 and 3) that will; • improve students access to experiential applied STEM learning opportunities • enable students to make informed choices about progression to higher level STEM related pathways • improve the visibility of STEM capabilities within assessment standards		MoE		
		School science community partnerships that support school		MoE		A pilot will run through to July 2014 to build school science community

		students' science learning. The aim is to develop sustainable linkages between the science education community and schools to make the most of New Zealand's collective strengths and resources.				partnerships that support school students' science learning, and test such a leadership and coordination role for strategic effectiveness to inform a wider system change in 2015-16.
	Review and update the provision of ICT including its positioning within the framework of the New Zealand Curriculum	The Ministry will work alongside sector partners to review and update the provision of ICT including its positioning within the framework of the New Zealand Curriculum.:		MOE		It is intended this will result in additional guidance and support materials exemplifying ICT provision across primary and secondary years and will complement the National Certificate of Educational Achievement (NCEA) review and maintenance programme.
Public engaging with the science sector	Support quality science journalism and blogging in the multi-platform media	The Science Media Centre – a centre that translates science and technology issues for the media and educates scientists on engaging with the media to improve the quality and professionalism of science and technology reporting		MBIE		Enhance the role and reach of the Science Media Centre to support more training and outreach to science journalists to encourage responsible and insightful science news reporting and long-form analysis that is relevant to the New Zealand public.
	Support quality national initiatives on science and technology	Establish a contestable fund for nationally-delivered initiatives that deliver on the plan and target hard to reach groups and could not proceed without government support		MBIE		To be designed and piloted in 2014/15 and implemented in 2015/16.
	Support youth into science and technology-based careers	The STEM feature in the 2014 Occupation Outlook identified the current and future demand for STEM-related careers		MBIE		To consider its future in 2014
		Youth Transitions Framework that focuses on more young people participating in learning areas of high growth and demand (eg STEM subjects)		TEC		
		Identification of STEM-related Vocational Pathways credits that will enable secondary and tertiary students to achieve foundation level credits for progression towards higher level STEM-related qualifications		MoE, TEC		
		Partnering with the on-campus support group for Māori and Pasifika students		TPK	Te Rōpū Āwhina in the Victoria University	
		Māori Future Makers website which profiles Māori and whānau in non-traditional, knowledge intensive sectors		TPK		
		Partnering through the LenScience programme to support teachers in up to 20 secondary schools in Auckland with high numbers of Māori students to deliver tailored science curriculums to meet the needs of Māori students.		TPK	Auckland Uniservices	
		Universities, polytechs/institutes of technology and other tertiary education institutions have extensive relationships with schools, with a range of current initiatives between the tertiary sector and schools.				

		Work with Careers NZ to explore and develop ways to raise awareness of science and technology careers on the Careers NZ website.		Careers NZ		
		Supporting Young Achievers Awards		MBIE		
		Talented School Students Travel Awards		MBIE		Modify to [to come]
		Continue work to develop and promote the uptake of information provision for learners about science careers		MoE		
		Utilise Vocational Pathways to support schools to design curriculum programmes that contextualise learning in ways that better meet learners' needs and interests, including science and technology education		MoE		
		Consider how to strengthen science literacy in senior secondary schooling particularly at year 11		MoE		
		Promoting STEM careers to students through the FutureinTech programme		Callaghan Innovation		In 2014/15 explore more strategic targeting of the programme, and other potential changes to increase its impact
		[MWA and MoE to add text on actions addressing underrepresentation of girls and women in studying and working on STEM]				
	Build and maintain meaningful linkages between science and technology-led businesses, educators and learners and practising scientists and technologists	Establish mechanisms to connect business, local government, educators and the science community at a regional, industry or sector level		MBIE		To be designed and piloted in 2014/15 and, subject to the results of the pilot, implemented in 2015/16.
	Build greater connectivity with museums, zoos and science centres	Work with museums and science centres to agree their role in delivering on the plan		MBIE, MCH		To come
	Build the evidence base on public attitudes to, and engagement with, science and technology	Regularly survey public attitudes to, and engagement with, science and technology		MBIE		
Science sector engaging with the public	Ensure publically funded scientists employ leading edge knowledge and	The Prime Minister's Science Prizes and the Rutherford Medal – prizes for scientific research or technological practice that raise the profile and prestige of science				
		Government expectations on researchers receiving public funds to make research public and provide		MBIE, TEC		From 2015/16 to review and update the knowledge translation expectations attached to direct purchase /grants for

	international best practices to engage relevant public(s) in identifying priority research questions and usefully disseminating results	public engagement and outreach				research and contracts, and assess the current state of publically-relevant knowledge transfer practice among funding recipients. Results of this exercise can be used to inform training material for grantees and future decisions about the research funding
		The Crown Research Institute's (CRIs) Statement of Core Purpose includes statements on engagement with key stakeholders and to transfer technology and knowledge to key stakeholders		MBIE, CRIs		
		Expectation in the request for proposals for the first ten National Science Challenges sets expectations for engagement by the science sector with the public		MBIE		Build on the success of the public engagement process used to identify the National Science Challenges by considering the adoption of a similar approach to engaging the public in the implementation phase of the National Science Challenges
		Work with the scientific community to develop a Code of Practice for Scientists that enshrines their public responsibilities.		PMCSA	RSNZ	To begin in 2014/15. A recent model of such a commitment is the Japanese Council of Science's recently updated Code of Conduct of Scientists, which outlines not only the respons ble conduct of research but also the social responsibility of scientists to engage with the public and policy makers based on their expert knowledge.
	Increase the prominence of the work of Māori researchers in science/pūtao and of all researchers engaged in mātauranga Māori	Engage with researchers who are Māori, iwi, and Māori organisations about their mātauranga Māori and science knowledge and science projects to build connectivity		MBIE, PMCSA		To begin in 2014/15.
	Ensure emerging scientists and technology researcher have the basic communicatio n skills to make their research accessible to relevant audiences beyond their peer group	Work with the tertiary sector to identify ways to ensure that all emerging science and technology researchers have access to training that supports engagement and the dissemination of their knowledge to non-academic audiences.		MBIE, TEC		
Across all strategic action areas		Provide a Participatory Science Platform		MBIE, MoE		To be designed and piloted in 2014/15 and implemented in 2015/16.

References

[1] The 'leadership challenge' recommended by the National Science Challenges Panel in its report *Report of the National Science Challenges Panel, 27 March 2013* was called the 'Science and Society leadership challenge. This *plan uses 'Science in Society' is intended to convey the message that science is part of, as opposed to additional to, society.*

2 Immigration NZ: www.immigration.govt.nz/essential skills.htm.

[3] *The New Zealand Productivity Commission Working Paper 2014/01: An International Perspective on the New Zealand Productivity Paradox, April 2014: 8.*

4 France and Compton Bringing Communities Together.

5 Susanna Priest, Critical Science Literacy: What Citizens and Journalists Need to Know to Make Sense of Science, Bulletin of Science Technology & Society 2013 33: 138

6 See footnote 33.

7 Over the past three decades, the global perspective on the place of science in societies has changed from the assumption by academics and policy makers of undifferentiated 'public' that was seen as scientifically "illiterate, apathetic or even hostile towards science and technology". There is now better awareness and recognition of the multiple contextualised audiences for science and the distinct ways that they engage with it. In short, the focus has shifted from trying to remediate a perceived public deficit to recognising that any negative sentiment toward science and technology is very likely more about social values and citizens' trust than it is about the lack of public knowledge of scientific facts. Governments and organisations that recognise this, have rightly shifted their focus on creating context appropriate opportunities for dialogue and input into decisions about what society wants science to do for us all and how to make that happen.

8 Programme for International Student Achievement Draft Science Framework.p3.

9 Madsen, JB. 2010. The Anatomy of Growth in the OECD since 1870. Journal of Monetary Economics, v57(6) pp 753-67.

10 New Zealand Government Business Growth Agenda: Progress Report 2013.

11 Ministry of Business, Innovation and Employment Occupation Outlook 2014, p7.

12 Ministry of Business, Innovation and Employment Occupation Outlook 2014, p8.

13 Ministry of Business, Innovation and Employment Occupation Outlook 2014, p7.

14 New Zealand Curriculum 2007.

15 Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies' OECD Publishing, 2012. http://dx.doi.org/10.1787/9789264177338-en,

16 http://www.careers.govt.nz/plan-your-career/helping-young-people-make-decisions/what-things-influence-a-young-persons-career-decisions/ and 'STEM Careers Awareness Timelines: Attitudes and ambitions towards science, technology, engineering and maths' Jo Hutchinson, Peter Stagg and Kieran Bentley, University of Derby, 2009. www.derby.ac.uk/files/icegs_stem_careers_awareness_timelines.pdf

17 This survey, Science and the General Public 2010, was commissioned by the Ministry of Research, Science and Technology. Similar surveys were also commissioned in 2002 and 2005.

18 Rosemary Hipkins, 'Public Attitudes to Science: rethinking outreach initiatives' New Zealand Science Review 67.4, 2010, p109. The 44% of New Zealanders with a detached interest in science are described in the survey as a 'mainstream group'. This group understands that science is important, but they do not consider it is relevant to their busy, everyday lives. They perceive that: science information lacks relevancy; they receive too much or too little information; they lack trust in scientists and lack understanding of career pathways for their children / young relatives.

19 For example, Eurobarometer 73.1: Science and Technology Report 2010, European Commission, 2010 and Public Atitudes to Science 2011. Main Report. Ipsos Mori Social Research Institute/Department of Business, Innovation and Skills (UK) May 2011. http://ipsoso-mori.com/Assets/Docs/Polls/sri-pas-2011-main-report.pdf

20 35% of New Zealand adults have a secondary qualification and a further 21% have a tertiary qualification New Zealand Census 2013.

[21] *NAP, On Being a Scientist 2009.*

22 This includes: $927m from Vote Science and Innovation; $313m from Vote Education; $98m from Vote Primary Industries and $18m from other government Votes.

23 The appropriations in Vote: Culture and Heritage for 2013/14 are $134,417m (for public broadcasting services) and $33.094m (for museum services). The $33.094m (for museum services) funds the Museum of New Zealand Te Papa Tongarewa.

24 Rowe et al, 'Difficulties in evaluating public engagement initiatives: reflections on an evaluation of the UK GM Nation public debate about transgenic crops' Public Understanding of Science, v14 (2005), pp331-352.

25 Meltwater Statistics http:/www.sciencemediacentre.co.nz/five-years-of-science-in-the-media.

26 Immigration NZ: www.immigration.govt.nz/essential skills.htm.

27 Ministry of Business, Innovation and Employment Occupation Outlook 2014, p8.

28 Inspiring Australians

29 www.ipenz.org.nz/ipenz/forms/pdfs/NEEP Project Report.pdf.

[30] *Ministry of Education 2012 data (Profile & Trends: New Zealand's Tertiary Education Sector, http://www.educationcounts.govt.nz/publications/series/2531/profile-and-trends-2012).*

[31] *Association for Women in Science Snapshot: Encouraging women to use and develop their scientific abilities to achieve their full potential, 2011.*

32 http://www.wipo.int/export/sites/www/freepublications/en/economics/gii/gii_2013.pdf, page 290 School life expectancy, primary to tertiary education (years) | 2010

33 From 2008-2010 students with more than 14 credits in science rose from 73.2% to 73.5% and then dropped in 2011 and 2012 to 71.4% and 71.6% respectively.
34 Trends in International Mathematics and Science Study.
35 OECD, Programme for International Student Assessment 2012.
36 Prepared by the Ministry of Education from data from the Programme for International Student Assessment.
37 Hipkins, R and Bolstad R. 2005. Staying in Science. Students' participation in secondary education and on transition to tertiary studies; and the follow-up study Staying in Science 2 (by Hipkins, R, Roberts, J, Bolstad R and Ferral H. 2006) NZ Council for Educational Research. Also NMSSA and Education Review Office Science in Years 5 to 8: Capable and Competent Teaching (May 2010): 01/05/2010.

Annex 1: Initial Science in Society strategic plan

Science for, by, and with New Zealanders

He pūtaiao mā Aotearoa, nā Aotearoa, me Aotearoa

A national strategic plan for science in society

Contents

Ministers' foreword

[To be drafted]

Steven Joyce
Minister of Science and Innovation

Hekia Parata
Minister of Education

Executive summary

The nature of science and its role in advancing society's interests has changed in recent decades. Science and the knowledge and innovation that flow from scientific progress have a central role in creating and defining our future. Science can no longer be perceived as being isolated from the rest of societal functions. It must be well embedded in everything we do. Society has as much stake in what research is undertaken, why it is done and how it gets used as those who generate this knowledge. Understanding and making the most of this relationship between science and society is critical to a vibrant and healthy nation.

Many of today's most complex decisions (e.g. on public health, natural resources stewardship and communications technology) require us all to weigh scientific evidence and social values. New Zealanders should feel encouraged and equipped to engage in the key questions facing our society now and in the future. The Government's goal of economic growth through an innovation society drives the need for an increasingly science, technology, engineering and mathematics (STEM) competent workforce.

This plan has been developed in response to the Science in Society leadership challenge'[1] recommended by the National Science Challenges Panel. The Panel saw it as "the most important challenge to address" and central to the success of the National Science Challenges. In May 2013, the Government formally accepted the leadership challenge and this plan is the response.

The Government's primary objective for Science in Society is to 'encourage and enable better engagement with science and technology across all sectors of New Zealand' in order to deliver the outcomes of:

- a more scientifically and technologically engaged public and a more publically engaged science sector; and
- more science and technology competent learners choosing STEM-related career pathways.

In the longer term it is anticipated that progress towards these outcomes will contribute to New Zealand's economic growth and social and environmental well-being through:

- a greater number of New Zealanders with the skills needed to support creativity, innovation and knowledge uptake and use;
- publically funded science and technology which responds to the needs of New Zealanders; and
- New Zealanders making more informed decisions on issues of importance to 21st century life.

A 2010 survey of public attitudes to science identified that about half of New Zealanders are actively interested in science and the other half do not recognise the relevance of science in their everyday lives (44%) or are disengaged (9%). There is limited evidence on the level and effectiveness of the engagement of the science sector with the public.

[1] The 'leadership challenge' recommended by the National Science Challenges Panel in its report *Report of the National Science Challenges Panel, 27 March 2013* was called the 'Science and Society leadership challenge. This plan uses 'Science in Society' is intended to convey the message that science is part of, as opposed to additional to, society.

Growth in employment in STEM occupations is forecast to be strong over the period 2011-2021. In 2012, 37% of domestic students completed qualifications at bachelor's level and above in health; natural and physical sciences; engineering and related technologies, IT, and architecture and building. However, New Zealand school student performance in science and mathematics is declining.

The challenges ahead are:

- increasing the engagement of New Zealanders, across all sectors, with science and technology and increasing the effectiveness of the science sector's engagement with the public; and
- increasing the numbers of learners with STE competencies to meet the needs of 21st century citizenship and labour market.

These are long-standing challenges that will take time to address. The plan sets out a direction for the next 10 years and a plan of action for the next three years.

Some progress has been made towards encouraging and enabling engagement by New Zealanders with science and technology. However, to deliver on the objective and outcomes in this plan a step change is needed.

This plan will focus on three Strategic Action Areas and one integrating Strategic Action:

- ***Strategic Action Area one***: further enhancing the role of the education sector
- ***Strategic Action Area two***: public engagement with science and technology
- ***Strategic Action Area three:*** science sector engaging with the public
- ***Integrating Strategic Action:*** participatory science platform.

The three Strategic Action Areas are interconnected, as each supports the other, while a key component of this plan is the Participatory Science Platform, which contributes to all three. The advice of the Science in Society Reference Group is that any action in the education sector must be complemented by support from the wider school community. Enhancing public engagement with science and technology cannot be separated from encouraging scientists to engage effectively with the public. This plan addresses the barriers and enablers to creating a more 'publically engaged' science sector together with a more 'scientifically engaged' public.

This plan recognises and acknowledges the importance of mātauranga Māori to build cultural confidence and identity, and how, through this, New Zealand can grow its skills and generate innovation and creativity. Mātauranga Māori is Māori knowledge that is dynamic, building from earliest traditions to future knowledge. Each of the three Strategic Action Areas and the Integrating Strategic Action will be developed in ways that respect whānau, hapū and iwi as the key conduits of mātauranga Māori, and focus on realising the potential gain for New Zealand through building Māori capability in science and technology to support Māori development and management of natural resources.

The Ministry of Business, Innovation and Employment's Vision Mātauranga policy aims to unlock the science and innovation potential of Māori knowledge, people and resources for the benefit of New Zealand. The Vision Mātauranga policy is embedded across science investments, and as such forms a core component for the implementation of MBIE's approach to supporting outcomes that benefit Māori and New Zealand.

As this is New Zealand's first Science in Society strategic plan, in 2015 it will be accompanied by an ongoing process of review and response to changing needs and contexts. The Science in

Society Steering Group, which includes operational links to the growing network of departmental science advisors (He Rauhinga Tohu Pūtaiao) chaired by the Prime Minister's Chief Science Advisor, and the Science in Society Reference Group will assess progress on the plan and advise government on any modifications needed to the actions to better deliver on the outcomes.

The Ministry of Business, Innovation and Employment and the Ministry of Education, together with the Office of the Prime Minister's Chief Science Advisor, will oversee implementation of the plan by government agencies, iwi and other sectors including the education, science, business and museum sectors. The two agencies will also lead a process of engagement with the public on the plan and the strategic actions in it.

The plan recognises the importance of mathematics skills as part of the overall package of STEM skills. However, it does not specifically address increasing the supply of students with mathematics competencies as this is being addressed by the literacy and numeracy taskforce.

PART 1 Setting the Scene

Science and technology are critical components of society's efforts to enhance people's standard of living through economic growth and enhanced social conditions, while protecting the environment. Today, there is a recognition that science is embedded in the many decisions societies must make - whether in public policy, business or the decisions of individuals. Societies with strong "science capital[2]" are sustaining more innovative economies, and there is a greater awareness of both the opportunities and limits of science in development and wellbeing. Science is central to the many global challenges we face (from climate change to an aging and increasingly urban population, for instance). The Government has recognised the importance of science. In 2009, it established the Office of the Prime Minister's Chief Science Advisor (PMCSA) to assist in progressing understanding of the role of science both in government and by the public. Progress was revisited as a result of the work of the National Science Challenges Panel chaired by the PMCSA.

1.1 The National Science Challenges and the leadership challenge

Following significant public engagement in early 2013, the National Science Challenges Panel recommended a set of national science challenges to address our most pressing health and environmental issues, and to advance our economy through innovation. The Panel also recommended a 'Science in Society leadership challenge' that they saw as "the most important challenge to address" if New Zealand is to advance through the responsible application of science and innovation and benefit optimally from its investment in scientific research. The Panel considered the 'Science in Society leadership challenge' to be central to the success of the National Science Challenges.

The 'Science in Society leadership challenge' asked government to take a lead in facilitating better engagement with science in New Zealand in four distinct but interrelated areas:

1. Science, technology, engineering and mathematics (STEM) education in primary and secondary schools.

2. 'Public understanding of science', including both the potential and the limits of scientific knowledge and managing uncertainties. Here, 'public' is understood in a pluralistic sense and necessarily includes the elected representatives and public servants that work in the interest of the New Zealand public.

3. Early engagement by citizens and other knowledge users on the implications of new technologies and novel applications of existing technology, and to help ensure the public relevance of New Zealand's science and research agenda.

4. National capacities in technology assessment, risk forecasting and using this in developing societal consensus in using and limiting technologies.

In May 2013, the Government formally accepted the 'Science in Society leadership challenge', with the Minister of Science and Innovation and the Minister of Education subsequently announcing development of this strategic plan in November 2013. In order to manage the

[2] Science capital refers to science-related qualifications, understanding, knowledge (about science and 'how it works'), interest and social contacts (e.g. knowing someone who works in a science-related job). This definition is from *Aspires Young people's science and career aspirations, age 10-14,* Department of Education and Professional Studies and King's College London: 13.

scope of the plan the technology assessment and risk forecasting area is not addressed in the plan at this stage. Annex 1 sets out the process used for developing this plan.

1.2 Methodology for developing this plan

The plan sets out the objective and outcomes the Government wishes to achieve for Science in Society over the next 10 years. It sets out the available evidence on where New Zealand is at now and identifies the challenges that need to be addressed. It concludes by setting out a three-year plan of action to make progress towards the objective and outcomes.

1.3 Scope of the plan

The plan focuses on supporting and equipping New Zealanders to engage in the key questions facing society and the supply of STE skilled people through the primary, secondary and tertiary education system. The plan does not cover the supply of mathematics skills and demand for STEM skills as these issues are being addressed through the Business Growth Agenda and literacy and numeracy taskforce. It does not address the government's current and proposed future priorities for its public science investments as this is covered by the National Statement of Science Investment. It also does not address adult mathematics literacy as the Government is addressing these issues through initiatives including the Tertiary Education Commission's Adult Literacy and Numeracy Implementation Strategy.

1.4 Audiences

The plan is addressed to all New Zealanders. To be effective, it is important to be specific about target audiences where strategic actions can make the most difference. In particular, the plan recognises that there are certain stakeholders in our social relationship with science that are important 'agents of change.' These are:

- *Students, teachers and the compulsory learning sector*: today's learners are tomorrow's decision-makers who will engage in increasingly complex societal issues where science and technology may be either a cause of or a solution to problems. New Zealand needs a skilled workforce to push the boundaries of enquiry and innovation in an increasingly knowledge-led global economy.

- *Parents, whānau and communities:* important learning environments are in homes, communities, Early Childhood Education Services and schools/kura across New Zealand, where an engagement with science and technology is role-modelled to our learners.

- *Business, especially science and technology-led businesses:* we need innovative science and technology-led businesses to grow our economy and employ skilled workers and a vibrant business sector to inspire future creators of science and technology-led businesses.

- *The public sector and government*: one way in which the public engages with science is through the decision-makers it elects. The relationship between elected officials, the public sector and New Zealanders is built on trust that decision-makers consider the best available evidence in public policy decisions.

- *Communicators of science and technology, including media, internet, museums, zoos, science centres and industry organisations*: many New Zealanders engage with science and technology through reporting by the media and on the internet and visits to

museums, zoos, science centres and industry organisations. We need accurate, contextualised information presented in an engaging way.

- *The science sector:* teachers, students, the public, businesses, the media, public servants and government decision-makers should not be expected to identify, digest, analyse and act on raw scientific knowledge. To be relevant and useful, knowledge needs to be made accessible and contextualised. The science sector (including funders and researchers) needs to be enabled to improve sharing and 'translation' of the knowledge it is producing.

1.5 Key definitions

What do we mean by 'science', technology and STEM?

Science is a set of formal processes that interrogates the "real things" or phenomena of the natural and social world in order to construct explanations of them, that is, to know the world.[3] It describes a way of thinking about the world, a creative process which generates knowledge and the ability to think critically about that knowledge. *The New Zealand Curriculum* describes ***science*** as "*a way of investigating, understanding and explaining our natural, physical world and the wider universe.*"[4] It involves generating and testing ideas, and gathering evidence through various means which include observation, investigation, modelling and communication and debate with others to develop scientific knowledge, understanding and explanations.

Science knowledge means both knowledge of the processes, methods, and facts of science on one hand, and knowledge about science's applications and limitations on the other. Certain audiences will specialise in knowledge 'of' science, but basic knowledge 'about' science is broader and is an important tool of 21st century citizenship and public discussion on today's most pressing societal concerns. This has been referred to as 'critical science literacy[5]'. We also acknowledge that 'knowledge' may also mean the science sector's own knowledge of various public audiences and how to connect with these to make their science relevant.

Technology intervenes in the world to solve problems, meet needs or desires, that is, to create part of the made world[6]. *The New Zealand Curriculum* describes ***technology*** as "*intervention by design: the use of practical and intellectual resources to develop products and systems that expand human possibilities by addressing needs and realising opportunities. Adaptation and innovation are at the heart of technological practice...which is never static*".[7]

STEM is the internationally recognised term that refers to subjects or areas of learning, namely science, technology, engineering and mathematics, which are used broadly and are inclusive of all levels of learning. Often, the acronym is used as shorthand to denote the family of numerate subjects, even when one or more are not considered. In the plan, we distinguish deliberately between **STEM** and **STM**, which refers to compulsory level subjects (science, technology and mathematics) because engineering is taught only at tertiary level. **STE** refers to science, technology and engineering subjects.

What do we mean by 'engagement'?

Engagement' can and should be a range of things for different people and different times, and is dependent upon purpose.

[3] France and Compton *Bringing Communities Together.*
[4] *The New Zealand Curriculum*, p28
[5] Susanna Priest, *Critical Science Literacy: What Citizens and Journalists Need to Know to Make Sense of Science, Bulletin of Science Technology & Society 2013 33: 138*
[6] See footnote 33.
[7] *The New Zealand Curriculum*, p32

The goal of 'engagement' in the plan is to recognise and enable the role that we all have in understanding, becoming informed and questioning what we need science to address and what we do with the new knowledge that science produces.

In some instances, this is through the opportunity to learn in a more hands-on and relevant way that can help shape our attitudes and decisions. In other situations, it is a participatory tool for a more open approach to research and for making decisions about how to use the information it produces. This is one way that a stronger relationship between science and society can be developed.

For the public (including government) 'engagement' means the acquisition and application of multiple types of STEM-knowledge by multiple kinds of audiences for various purposes.

For the science sector it involves communicating new knowledge clearly for different users, as well as undertaking research and responding to the knowledge needs of society.

Taken together these characteristics of 'engagement' imply an improved and productive social relationship between the science sector and wider society that will lead to the responsible application of knowledge for the social, environmental and economic wellbeing of New Zealanders.

Thus, in the plan, the focus is on engagement in:

- *acquiring knowledge*, which is about the public, including and especially compulsory level learners acquiring the STE skills and knowledge needed to develop a career in science and/or to engage in much needed and ongoing public conversations about the application of scientific knowledge and technology.

- *generating knowledge*, which is about knowledge users, including the public, being enabled to help identify issues requiring science input so that public science research is more relevant and stands to have more meaningful impact. It is also about the public being part of the research itself, including through opportunities in Participatory Science.

- *applying knowledge*, is about being enabled to make the best use of what we know, including the responsible and evolving use of or limiting of new technologies or novel applications of existing technology.

This definition of engagement reflects a fresh approach through a necessary mix of what has in the past been called 'public understanding of science' or 'science literacy' and of 'public engagement in science'[8].

[8] Over the past three decades, the global perspective on the place of science in societies has changed from the assumption by academics and policy makers of undifferentiated 'public' that was seen as scientifically "illiterate, apathetic or even hostile towards science and technology". There is now better awareness and recognition of the multiple contextualised audiences for science and the distinct ways that they engage with it. In short, the focus has shifted from trying to remediate a perceived public deficit to recognising that any negative sentiment toward science and technology is very likely more about social values and citizens' trust than it is about the lack of public knowledge of scientific facts. Governments and organisations that recognise this, have rightly shifted their focus on creating context appropriate opportunities for dialogue and input into decisions about what society wants science to do for us all and how to make that happen. Jasanoff, S. *A mirror for science*. In: *Public Engagement in Science*: Special Issue Vol. 23(1) 21-26. 2014.

PART 2 Making the Case

2.1 Why science in society matters

21st century life is driving the need to increase our engagement with science and technology

Many of today's toughest decisions at local, national and international levels – about public health; natural resources stewardship or new and emerging technologies for instance – require all of us to weigh both scientific evidence and social values. The National Science Challenges are science priorities that respond to the most important, national scale issues and opportunities identified by science stakeholders including the New Zealand public. Many of these and other challenges we face today and into the future will require creative and innovative solutions that have a basis in scientific discovery and technological application[9]. New Zealanders should feel encouraged and equipped to engage in the key questions facing our society now and in the future.

Science is often at the heart of challenging social, environmental and economic issues – as a solution to, and sometimes a cause of the issues we face today.

The production and application of scientific knowledge and new technologies often imply trade-offs that we need to weigh carefully: how to prioritise research investment and the potential for unintended consequences. These are complex issues for society to consider which no one group, such as scientists, government or businesses, should make on behalf of New Zealanders without their input.

However, addressing such questions requires 'social licence' for action to be taken. 'Social licence' is never guaranteed and depends upon an environment of mutual understanding and transparent and deliberate communication between the public and science sector.

This plan is the Government's initiative to create the environment needed for social licence to occur by supporting change across the many sectors that can have impact over the next several years.

The goal of an 'innovation' society is driving the need for an increasingly STEM competent workforce

New Zealand's economic and social wellbeing depends on the productivity and competitiveness of the economy and the knowledge we have to help make informed decisions as a society. Innovation that leads to increased productivity and promising solutions to society's most pressing concerns is increasingly being seen around the world as an important way to generate economic growth and improved living standards[10].

The Government is committed to developing an 'innovation society' by materially lifting New Zealand's long-run productivity growth while maintaining our high rate of labour force participation[11], and by ensuring that we use the knowledge produced here and elsewhere to improve the policies and practices that affect us all. To do this, New Zealand needs a high performing and responsive science and innovation system and skilled people who can problem-

[9] *Programme for International Student Achievement Draft Science Framework.p3.*
[10] *Madsen, JB. 2010. The Anatomy of Growth in the OECD since 1870. Journal of Monetary Economics, v57(6) pp 753-67.*
[11] *New Zealand Government Business Growth Agenda: Future Direction 2014.*

solve, create and deliver high-value products and services for sustainable economic, social and environmental wellbeing. We also need businesses, policy makers and citizens that are ready to absorb and apply new ideas and approaches.

Our science system – particularly the tertiary education organisations that undertake research-led teaching – has a vital role in educating a future generation of scientists with the advanced science skills that are needed in leading-edge businesses. New Zealand has to be seen internationally as an 'innovation destination'. We must be able to attract and retain the right talent at the right time to contribute to our vital science. Attracting overseas and domestic investment in our research is also important for our economic growth.

A creative and innovative culture and a wide range of skills are needed for innovation, societal advancement and sound environmental stewardship. Internationally STEM skills underpin the development of new practices and technologies, the application of existing technologies and the development of new, high-value products[12]. STEM skills and competencies also underlie growth in many industries, such as IT-related industries[13] and are highly transferable across industries[14].

STEM skills, like other kinds of skills, are acquired by individuals over time and in a wide range of ways. They need to be developed as part of the key competencies for life-long learning[15]. An individual with higher levels of competency has a much lower likelihood of experiencing both economic and social disadvantage than an individual with lower competency levels[16].

Students' career choices are influenced beyond school / kura by family, whānau, iwi, business and the wider community, with parents providing the most important influences[17]. Greater community engagement with science and technology could increase the value students and their family or whānau place on the opportunities STEM subjects offer as career pathways.

The Ministry of Education (MoE) is focused on ensuring that the education system delivers on the Government's key goals of improved outcomes for all New Zealanders, and stronger economic growth for New Zealand. It is the lead agency on boosting skills and employment. Our ultimate goal is to equip young people with the skills to live a fulfilling life and contribute to New Zealand's economic prosperity.

The Ministry of Business, Innovation and Employment (MBIE) aims to grow New Zealand for all. New Zealand's economic and social wellbeing depends on the productivity and competitiveness of our economy and the knowledge we have to help make informed decisions as a society. Science provides that knowledge and informs those decisions. The science system contributes know-how for economic growth, helps to identify and manage risks in the natural world, and

[12] *Ministry of Business, Innovation and Employment Occupation Outlook 2014, p7.*
[13] *Ministry of Business, Innovation and Employment Occupation Outlook 2014, p8.*
[14] *Ministry of Business, Innovation and Employment Occupation Outlook 2014, p7.*
[15] *New Zealand Curriculum 2007.*
[16] *Better Skills, Better Jobs, Better Lives: A Strategic Approach to Skills Policies' OECD Publishing, 2012. http://dx.doi.org/10.1787/9789264177338-en,*
[17] *http://www.careers.govt.nz/plan-your-career/helping-young-people-make-decisions/what-things-influence-a-young-persons-career-decisions/ and 'STEM Careers Awareness Timelines: Attitudes and ambitions towards science, technology, engineering and maths' Jo Hutchinson, Peter Stagg and Kieran Bentley, University of Derby, 2009. www.derby.ac.uk/files/icegs_stem_careers_awareness_timelines.pdf*

provides skilled researchers and workers to support an innovation economy. MBIE aims to increase the economic contribution of the skills, science and innovation systems.

2.2 Objectives of the plan

The objective of this strategic plan is to:

> Encourage and enable better engagement with science and technology across all sectors of New Zealand.

The expected outcomes are:

- a more scientifically and technologically engaged public and a more publically engaged science sector;
- more science and technology competent learners choosing STEM-related career pathways.

Outcome 1: a more scientifically and technologically engaged public and a more publically engaged science sector

We will know we're making progress on this when:

- a greater proportion of New Zealanders across all sectors of society are engaged with, and value, science and technology
- there is more in-depth media reporting on science and technology based on robust scientific evidence
- there are increased opportunities for the public to learn about, and be involved in, scientific research and uptake continues to grow across all tiers of society
- there are more opportunities for the public and the science sector to engage in discussion about societal use and limits of new technology and applications for existing technology
- publically funded research responds to the needs of New Zealanders and recognises the diverse needs and issues of communities.

Outcome 2: more science and technology competent learners choosing STEM-related career pathways

We will know we're making progress on this when:

- we achieve greater student demand for STEM courses and qualifications at all levels of the qualifications framework (1-10)
- we have developed greater teacher confidence in teaching for STM outcomes
- teachers have improved access to the resources they need to teach STM subjects and links between the STM curriculum and career pathways are clarified.

Outcome 3: a more skilled workforce and more responsive science and technology sectors

In the longer term, we expect that progress towards outcomes one and two will contribute to New Zealand's economic growth and social and environmental wellbeing through:

- a greater number of New Zealanders with the skills needed to support creativity, innovation and knowledge uptake and use
- publically funded science and technology which responds to the needs of New Zealanders
- New Zealanders make more informed decisions on issues of importance to 21st century life.

2.3 The state of play

How scientifically and technologically engaged are the public and how publically engaged is the science sector?

There is no current comprehensive measure of public engagement in science or technology or adult STEM literacy

It is difficult to measure public engagement in science and technology and there is no internationally accepted metric to capture it. The best New Zealand evidence is a survey of public attitudes to science in New Zealand[18]. The survey identified that about half of New Zealanders were actively interested in science and the other half did not recognise the relevance of science in their daily lives[19] (44%) or were disengaged in science (9%). Similar surveys have been done in other countries. However it is difficult to draw comparisons given differences in the questions[20]. The Government has not surveyed public attitudes to technology outside this survey.

Relative to comparable countries, a relatively high proportion of New Zealand adults have a secondary or tertiary qualification[21]. There is no data on the proportion of these qualifications that are in STEM subjects. From 2016 New Zealand will assess adult competencies in reading, mathematics and problem solving in technology-rich environments through the Programme for the International Assessment of Adult Competencies.

There is limited data on the level and effectiveness of the engagement of the science sector and science and technology communicators with the public

There is increasing recognition today of the broader social responsibility of scientists to engage with the wider public in meaningful ways[22]. It is difficult to track and measure this engagement, however, in part because it can take place in a great variety of venues and with various goals in mind. Two main ways that scientists fulfil public engagement is by conveying knowledge to governments to ensure science-informed policy and decision making, and through more direct engagement with the public.

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[18] *This survey, Science and the General Public 2010, was commissioned by the Ministry of Research, Science and Technology. Similar surveys were also commissioned in 2002 and 2005.*
[19] *Rosemary Hipkins, 'Public Attitudes to Science: rethinking outreach initiatives' New Zealand Science Review 67.4, 2010, p109.* The 44% of New Zealanders with a detached interest in science are described in the survey as a 'mainstream group'. This group understands that science is important, but they do not consider it is relevant to their busy, everyday lives. They perceive that: science information lacks relevancy; they receive too much or too little information; they lack trust in scientists and lack understanding of career pathways for their children / young relatives.
[20] *For example, Eurobarometer 73.1: Science and Technology Report 2010, European Commission, 2010 and Public Atitudes to Science 2011: Main Report. Ipsos Mori Social Research Institute/Department of Business, Innovation and Skills (UK), May 2011. http://ipsoso-mori.com/Assets/Docs/Polls/sri-pas-2011-main-report.pdf*
[21] *35% of New Zealand adults have a secondary qualification and a further 21% have a tertiary qualification New Zealand Census 2013.*
[22] *NAP, On Being a Scientist 2009.*

Despite the clear objectives, it is still difficult to measure the impact of these types of engagement[23]. It is also difficult to estimate the proportion of government expenditure on public engagement by science organisations. However, a proportion of the $1.4b[24] invested by Government in supporting science and innovation in New Zealand was spent by universities and science organisations on making research more accessible to end-users through communication, public outreach and public education. Other government investment in these organisations may also be spent on communication, public engagement and education.

There are also many local government and private sector organisations, such as industry training providers, zoos, museums, science centres, charities and businesses that engage with the public on science and technology for education, cultural and marketing reasons. The Government also invests $167m in public broadcasting services and funding museums[25].

Since the Science Media Centre was established in 2008, 'science' in the media has increased by 75%[26].

Use of evidence in policy development

The State Services Commission has recently undertaken a review of government agencies to identify where departmental science advisors could lift internal capabilities to take up research and new knowledge. A network of advisors chaired by the PMCSA will grow in responsibility as additional Science Advisors are appointed. These changes are expected to help strengthen the channels of communication with the science sector and progress will be monitored as departmental science advisor positions are filled. The network is required to report on progress to the State Services Commissioner in 12 months.

How competent are STEM learners and how many are choosing STEM-related career pathways?

There are STEM skills shortages

There are currently skills shortages for many kinds of scientists, engineers, technologists, health and ICT professionals[27]. Demand for workers in many STEM-related occupations is expected to grow due to a variety of factors[28]. In addition, many jobs not directly STEM-related require STEM competencies. Internationally it is estimated that up to 75% of high-growth jobs require STEM skills and competencies[29].

The number of NZ graduates is growing, but international demand is growing faster

[23] *Rowe et al, 'Difficulties in evaluating public engagement initiatives: reflections on an evaluation of the UK GM Nation public debate about transgenic crops' Public Understanding of Science, v14 (2005), pp331-352.*
[24] This includes: $967m from Vote Science and Innovation, $335 m from Vote Tertiary Education, $90m from Vote Primary Industries and $18m from other government areas.
[25] *The appropriations in Vote: Culture and Heritage for 2013/14 are $134,417m (for public broadcasting services) and $33.094m (for museum services). The $33.094m (for museum services) funds the Museum of New Zealand Te Papa Tongarewa.*
[26] *Meltwater Statistics http:/www.sciencemediacentre.co.nz/five-years-of-science-in-the-media.*
[27] *Immigration NZ: www.immigration.govt.nz/essential skills.htm.*
[28] *Ministry of Business, Innovation and Employment Occupation Outlook 2014, p8.*
[29] *Inspiring Australians*

The number of domestic students completing bachelor degrees across all fields of study has increased from 19,596 in 2005 to 25,350 in 2012. For example, in the natural and physical sciences the increase has been from 1,937 in 2005 to 2,649 in 2012. The numbers of degree-level engineering training places funded by the government has recently increased. The industry training providers are facing difficulties in growing engineering at technician and technology qualification levels[30]. In 2012, 15,560 domestic students, or 37%, completed qualifications at bachelor's level and above in health; natural and physical sciences; engineering and related technologies, IT, and architecture and building[31]. Girls and women are under-represented in studying and working in STEM, apart from the health and biological sciences[32].

There is a global demand for those with STEM qualifications. Those who gain the STEM qualifications required for job-shortage areas can often either be lost from New Zealand to the global job market or pursue alternative careers. MBIE estimates that fewer than half of New Zealand graduates work in the field in which they studied and highly skilled immigrants are often required to fill the gaps. However, it is expected to become increasingly difficult to attract these immigrants as wages rise in increasingly knowledge-intensive Asian economies.

New Zealand school student performance in science has declined

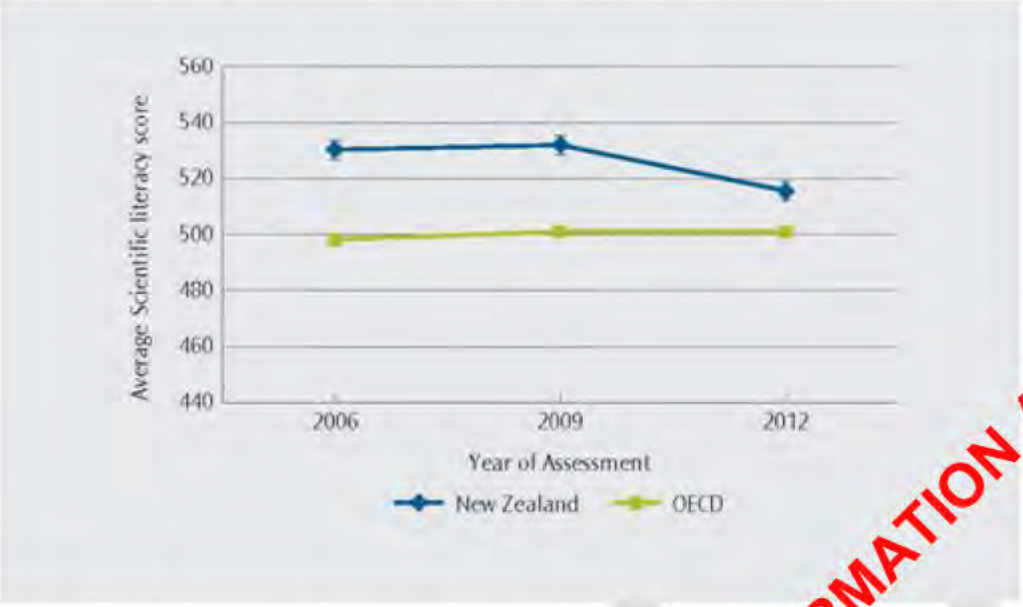
New Zealand has a highly respected education system. The World Economic Forum's Global Competitiveness Index for 2013[33] noted that New Zealanders spend the longest time in education from primary to tertiary, at 19.67 years and ranked New Zealand seventh for overall education indicators out of 142 countries.

Despite this, there is a gradual decline in the proportion of students enrolled in science-related subjects in years 11 to 13[34].

New Zealand students' performance in science has also declined, and the decline is more marked in the later years of schooling. The average performance of New Zealand year 5 students for science in 2010/11 was significantly lower than in 2002/3[35] and there has been no significant change in performance for year 9 students since 1994/5. The performance of New Zealand students at age 15 years (most students are in year 10 at this age) in science remained relatively stable up to 2009 and declined between 2009 and 2012[36].

[30] *www.ipenz.org.nz/ipenz/forms/pdfs/NEEP_Project_Report.pdf.*
[31] Ministry of Education 2012 SDR data*: New Zealand's Tertiary Education Sector, http://www.educationcounts.govt.nz/publications/series/2531/profile-and-trends-2012.*
[32] *Association for Women in Science Snapshot: Encouraging women to use and develop their scientific abilities to achieve their full potential, 2011.*
[33] *http://www.wipo.int/export/sites/www/freepublications/en/economics/gii/gii_2013.pdf, page 290 School life expectancy, primary to tertiary education (years) | 2010*
[34] *From 2008-2010 students with more than 14 credits in science rose from 73.2% to 73.5% and then dropped in 2011 and 2012 to 71.4% and 71.6% respectively.*
[35] *Trends in International Mathematics and Science Study.*
[36] *OECD, Programme for International Student Assessment 2012.*

Figure One: Graph showing changes in the average science literacy score for New Zealand students at 15 years between 2006 and 2012 compared to the OECD average[37]



The National Monitoring Study of Student Achievement (NMSSA) and the Programme for International Student Assessment (PISA) results also show growing inequity in student performance in science, particularly for Māori students and Pasifika students.

There is limited data on school student performance in technology

There is limited data on student performance in technology because it is not measured by PISA or the Trends in International Mathematics and Science Study (TIMMS), and NMSSA is yet to assess it.

What is causing the student performance decline?

Research suggests that student achievement in science is declining in part because science teachers are less confident in teaching science, particularly to diverse groups. Teachers do not always have access to the appropriate resources. Furthermore, some students lack confidence in their ability to succeed in STE subjects and lack support for deciding on senior secondary school subjects[38].

2.4 The challenges and how we can best address them

The challenges are:

- Increasing the engagement of New Zealanders, across all sectors, with science and technology and increasing the effectiveness of the science sector's engagement with the public
- Increasing the numbers of learners with STE competencies to meet the needs of their everyday lives and the 21st century labour market.

[37] *Prepared by the Ministry of Education from data from the Programme for International Student Assessment.*
[38] *Hipkins, R and Bolstad R. 2005. Staying in Science. Students' participation in secondary education and on transition to tertiary studies; and the follow-up study Staying in Science 2 (by Hipkins, R, Roberts, J, Bolstad R and Ferral H. 2006) NZ Council for Educational Research. Also NMSSA and Education Review Office Science in Years 5 to 8: Capable and Competent Teaching (May 2010): 01/05/2010.*

To address these challenges we need to:

- *Build a nationally supportive environment for public engagement in science and technology and, equally, for the science sector's engagement with the public.*

  This needs to focus on identifying, encouraging and supporting the most effective ways for the science sector and science and technology communicators (such as the media, museums and event organisers) to engage with the public, particularly young New Zealanders and those New Zealanders that are disengaged or do not see the relevance of science in their daily lives. The environment needs to encourage improved dialogue. There is already significant activity in these areas, so encouraging good practice and greater coordination is important.

- *Further improve teacher confidence through high quality science and technology teacher education, and provide support for quality teaching, learning and assessment in science and technology;*
- *Develop science and technology-specific curriculum experiences that build towards future-oriented approaches and support teachers to use them; and*
- *Improve linkages between STM educators, scientists, businesses, technologists and learners and the community.*

  These are the key levers that national and international research on effective teaching and learning in science and technology[39] have identified as critical for improving student engagement and achievement. A comprehensive and coherent programme of improvement that drives these levers and utilises all of the existing resources and expertise across the science and technology education systems is needed to meet the challenge of increasing the STEM competencies of New Zealand's young people.

PART 3 Strategic Action Areas and Priority Actions

Some action has been taken towards encouraging and enabling engagement by New Zealanders with science and technology. The government's current activities are described in Annex 2. However, to deliver on the objectives and outcomes in this plan a step change is needed.

In particular, further support is needed to help develop teacher confidence and science competencies at the primary level through initial teacher training; and at all other levels through continuing professional learning and development, and better links between practising scientists (including post-graduate researchers and private sector scientists) and schools.

Continued support is also needed to encourage effective ways for the science sector and other science and technology communicators to engage with the public, including through two-way dialogue, and further support is needed for good practice, greater impact and improved coordination.

The following section sets out 3 Strategic Action Areas (SAAs), each with a set of priority actions to be carried out over the next three years. These actions also maintain a view on the 10-year horizon, commensurate with the National Science Challenges.

In addition to these Strategic Action Areas, at the heart of this plan is a Priority Action that spans all three SAAs: the Participatory Science Platform. This platform (described in section 3.4) is especially designed to simultaneously:

- Work with the education sector to make it easier to bring "real-world" science into the classroom by connecting teachers with practising scientists (SAA1)
- Enable and foster the public's understanding of and engagement in real-world science through research that is relevant to local communities (SAA2)
- Offer opportunities for practising scientists to become better engaged with the public by contributing both to science education and to filling knowledge gaps that are locally relevant and scientifically interesting (SAA3).

3.1 Strategic Action Area 1: Further enhancing the role of the education sector

The principal goal of Strategic Action Area 1 is to support all young New Zealanders to be resilient learners with future-proofed skills to understand, assess and apply rapidly changing science and technology knowledge to their everyday lives. This goal will contribute to building creativity, innovation and increased critical science literacy. Strategic Action Area 1 will include a focus on quality teaching and learning, and providing additional opportunities to enhance competencies, confidence and dispositions that grow scientific knowledge, curiosity and creativity in students in partnership with schools / kura, families, whānau, iwi and the business and science communities.

The activities in Strategic Action Area 1 are focused on five key intervention sites: Early Childhood Education, primary level education; secondary level education; the transition to further study/training or employment; and science leadership.

Actions will explicitly focus on enabling a future-oriented science and technology education system. Integrative thinking for improving science and technology teaching and learning, skills and dispositions for innovation, and changes to pedagogical practice as e-learning and ICT evolves will be central. This will include how the focus of science education should differ at the different levels of schooling.

Actions include:

1. *Improve initial teacher education with increased science teaching competencies and confidence*. Early Childhood Education and primary teachers are necessarily generalists. New research has shown that early childhood and primary education is an important window of opportunity for imparting foundation curiosity and learning behaviours for learners' future attitudes and practices toward science and technology. To maximise this opportunity new primary teachers need the confidence and content knowledge to sustain student engagement and progress.

   Activities include:

   - MoE will work with initial teacher education providers, qualification accreditation bodies and relevant professional bodies to identify ways to lift the level of science content in initial teacher education. This could form a component of under-graduate qualifications for early childhood and primary education, and would be targeted to lift the confidence of graduating teachers to teach science (teachers currently report limited confidence, particularly at years 7-8).

2. *Improve the quality and relevance of continuing professional learning and development opportunities for teachers in science and technology.*

   The Minister of Education has appointed an Advisory Group with representatives from across the education sector to provide advice on the design of future professional learning and development (PLD) across the compulsory schooling sector. The group will

provide advice on what improvements should be made to the targeting of centrally funded PLD to achieve a system-wide lift in student achievement; and provide advice on how changes could be implemented to achieve the maximum impact.

The Government spends more than $80 million every year on PLD to support the development of a highly capable profession, and a PLD system that builds the skills of teachers and education leaders. This investment is intended to deliver measurable gains for students across the curriculum, including science/pūtaiao, technology/hangarau and mathematics/pāngarau.

In 2014 approximately $5,663,709.00 was appropriated to science and technology PLD. This figure does not include the science and technology PLD which is inside other contracts, and that schools can apply for on the basis of need.

Activities in this area include:

- Providing teachers of science in years 1 to 10 with opportunities to work with research organisations to develop leadership skills and enhance the teaching of science within school communities.
- Promote the Science/Biotechnology Learning Hubs to provide a high-quality online repository of New Zealand science and resources to support science education for teachers, students and communities.
- Create a Science Skills in Education Initiative to support schools and teachers to build confidence and access resources to develop rich, contextualised science programmes that are exciting for students, including assisting teachers to continue their science education, focusing on skills that reflect science/pūtaiao in the national curriculum, and expanding the availability of the Sir Paul Callaghan Academy initiative. This initiative focuses on teacher learning, and will explore links to the Teachers in Industry Project as appropriate.
- Create a Teachers in Industry Project for teachers, to connect schools with science intensive businesses to enable teachers to spend a period of time in the businesses to bring business relevant content into their science lesson plans. We estimate that establishing this programme would require a coordinator to connect businesses and schools, with the coordinator connected to both MBIE and the Ministry of Education.

3. *Build and maintain meaningful linkages between science and technology educators and learners, and practising scientists and technologists, both in the classroom and through opportunities that engage the wider community:* Partnerships with Tertiary Education Organisations, CRIs, private bodies, science organisations (such as museums, science centres, zoos, aquaria, observatories) and secondary-tertiary programmes that enable participants to experience tertiary-level educational activities, are all key for learning outside the classroom. These learning experiences outside the classroom need to be integrated meaningfully within teaching and learning programmes.

   Activities include:

   - Explore equitable funding models to enable schools / kura to meet the costs of students attending Learning Experiences Outside The Classroom.
   - Identify the assessment standards on the National Qualifications Framework (levels 2 and 3) that will improve the visibility of STEM capabilities within assessment standards.

- Develop and implement a Participatory Science Platform (described below at 3.4) that engages schools / kura, community-based groups and organisations and practising researchers in questions that are scientifically rigorous, locally relevant and pedagogically innovative. The platform includes central coordinator roles that will oversee the platform and be a conduit between learning environments and scientists.

4. *MoE will work alongside sector partners to review the positioning and content of digital technology within the framework of the New Zealand Curriculum and Te Mauratanga o Aotearoa*

3.2 Strategic Action Area 2: Public engaging with science

The goal of this Strategic Action Area is to build a nationally supportive environment for public engagement in science and technology. In addition, the Action Area is also designed to increase the number of such learners with an interest in STEM-related career pathways. This action area recognises the changing demographic of New Zealand including the increasing iwi and hapū asset base and the partnership model of service delivery. It operates with Strategic Action Area 3 to encourage greater dialogue between the science sector and the public by helping move toward 'a more scientifically engaged public' and 'a more publically engaged science sector'.

In the immediate term, the objective is to enhance the quality, breadth and depth of science communication to the public by the media, scientists, and organisers of national science and technology public events, support youth into science and technology based careers and build greater connectivity across sectors. In the longer-term, Strategic Action Area 2 recognises that the true culture change necessary to encourage and enable public engagement in science must start with young learners, their teachers, their families/whanāu and their communities.

1. *Support quality science journalism and coverage in the multi-platform media:* Print, television and online media (including socially networked media and blogging) are powerful tools for engagement with the public. This priority action will continue to harness the positive power of the media to help make science and the complexities of risk and scientific uncertainty more accessible.

   Activities include:

   - Enhance the role and reach of the Science Media Centre to support more training and outreach to science journalists to encourage responsible and insightful science news reporting and long-form analysis that is relevant to the New Zealand public.

2. *Support quality targeted initiatives on science and technology for traditionally harder-to-reach audiences:* There is a growing recognition internationally that efforts to engage the public in science and technology find their greatest success with people who are engaged in science. The challenge is to reach and inspire a broader base of New Zealanders through initiatives that bring science and technology to groups that are generally considered harder to reach. This action will support such initiatives with a broad reach, extending beyond a local area.

   Activities include:

   - Establish a contestable fund for targeted initiatives that deliver on the plan for harder to reach groups of the public and could not proceed without government support.

3. *Support youth into science and technology-based careers*: Continue to develop more responsive educational pathways, including the impacts of student study choices, and to develop entrepreneurial thinking in the science and innovation sector. The relevance of

science and technology learning to future career options needs to be made clearer at an earlier stage for learners, and the education and training pathways leading to these potential careers should be clarified.

Activities include:

- work with Careers NZ to raise awareness of science and technology careers on the Careers NZ website
- continue work to develop and promote the uptake of information provision for learners about science careers
- continue to support talented school students through young achievers and travel awards
- explore more strategic targeting of the FutureinTech programme, and other potential changes to increase its impact
- review and evaluate the pilot of the Science Education Leadership and Coordination role for merit to expand
- use the Vocational Pathways to design programmes that use real world contexts to deliver science and technology education in ways that engage learners' needs and interests
- consider how to strengthen science literacy in senior secondary schooling particularly at Year 11
- consider the future of the STEM feature in the Occupational Outlook
- consider how to increase girls' participation and achievement in science and ICT.

4. *Build and maintain meaningful linkages between science and technology-led businesses, science and technology educators and learners, and practising scientists and technologists:* Improving connections between science and technology-led businesses and learners will give more learners real world understanding of potential STEM career pathways. It will enable more science and technology-led businesses to promote STEM careers and build early connections with future employees and deliver growth and economic outcomes.
    - explore opportunities to better connect business, local government, educators and the science sector at a regional, industry or sector level.
5. Support *parents and whānau to increase their engagement with science*: The development of parental/whānau and community involvement acknowledges and builds on the importance of parents and families/whānau and local communities as young learners' first mentors, while also providing an opportunity to encourage parents' engagement with science through community collaborative research opportunities that bring together practising scientists with schools and other community organisations on real-world questions.

    Activities include:

    - Develop and implement a Participatory Science Platform (described below at 3.4). The platform will offer Early Childhood Education Services, schools / kura and their communities opportunities to participate in scientific research in projects with broad appeal, scientific value and pedagogical rigour that resonate with the community.