Consultant Report
Securing Australia's Future
STEM: Country Comparisons

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Science, Mathematics, Engineering and Technology (STEM) in Australia: Practice, policy and programs

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EXECUTIVE SUMMARY

Commonwealth government focus on school education, and science and innovation

School education, and science and innovation are national priorities for the Commonwealth government. The *National Plan for School Improvement* pledges access to a high-quality, high-equity education for every Australian school student, regardless of where they live, where they attend school or their personal circumstances. *Transforming Australia's Higher Education System,* the government's response to the Bradley review of Australia's higher education system (*Review of Australian Higher Education: Final Report*), commits to higher education expansion as a driver for Australia's knowledge-based economy. *Powering Ideas An Innovation Agenda for the 21st Century*, the government's response to the Cutler review of Australia's science and innovation sector (*Venturous Australia building strength in innovation)*, undertakes to enhance science and innovation, including research and development (R&D).

Key structural elements of the education, and science and innovation agendas at the federal level include the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), the Office of the Chief Scientist, the Department of Education, Employment and Workplace Relations (DEEWR) and the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE). In releasing the *Health of Australian Science*, the Chief Scientist, Professor Ian Chubb placed STEM firmly on the national agenda. Reflecting the government's prioritisation of education, and science and innovation the approach to science, technology, engineering and mathematics (STEM) is conceived in terms of school and university education, vocational training and skills formation, research and development, innovation and economic development, rather than as a coherent STEM-specific agenda.

Australia's school education system

In 2010 there were 9,468 schools in Australia, including 6,357 primary schools, 1,409 secondary schools, 1,286 combined primary and secondary schools and 416 special schools for students with disability. Most government and Catholic systems were primary schools (72 per cent), whereas most independent schools were combined primary and secondary schools (63 per cent) (Gonski et al., 2012[1]).

Australia's schools enrolled 3.5 million full-time equivalent students. The majority of school students (66 per cent) were enrolled in government schools, with the remainder enrolled in Catholic systemic and non-systemic schools (20 per cent), and independent schools (14 per cent) (*ibid*.). The number of school students has grown over the last decade, with greater growth recorded in independent schools (14 per cent) than Catholic schools (6 per cent) or government schools (2 per cent) (ABS, 2011 cited in Gonski et al., 2012).

Under the Australian Constitution, states and territories have responsibility for education, although both state and territory, and Commonwealth governments fund school and tertiary education. The Organisation for Economic Co-operation and Development (OECD) estimates that Australia's 2009 government expenditure on school and non-tertiary post-school level education (3.8 per cent of GDP) was the same as the OECD country average. Total spending on school and non-tertiary post-school education was 4.2 per cent of GDP

[1] Gonski, D, Boston, K, Greiner, K, Lawrence, C, Scales, B & Tannock, P 2011, *Review of Funding for Schooling - Final Report*, Australian Government, Canberra, viewed 28 December 2012 http://foi.deewr.gov.au/node/30439/.

compared to the OECD country average of 4.0 per cent, reflecting private investment in Australia's relatively large private school sectors (OECD, 2012, p. 245 and p. 269).[2]

Australian Curriculum

The Australian Curriculum, developed by the Australian Curriculum, Assessment and Reporting Authority (ACARA) is progressively being developed, spanning foundation (kindergarten) to senior secondary education. The Australian Curriculum defines learning areas, specifies general capabilities and establishes cross-curriculum priorities. The Foundation to Year 10 (F-10) Australian Curriculum includes the learning areas of Mathematics and Science, general capabilities in Numeracy and Information and Communication Technology, and cross-curriculum priorities in Aboriginal and Torres Strait Islander histories and cultures, Asia and Australia's engagement with Asia, and Sustainability. F-10 Australian Curriculum has been published, and states and territories have agreed to the phased introduction of this curriculum over the next few years. The *Australian Curriculum Implementation Survey* (ACARA, 2012[3]) reports on the state and territory implementation plans to introduce the F-10 Australian Curriculum, noting the phase-in period 2011-2014.

The Senior Secondary Australian Curriculum includes the learning areas of Mathematics (Essential Mathematics, General Mathematics, Mathematical Methods, Specialist Mathematics) and Science (Biology, Chemistry, Physics, and Earth and environmental science). The Senior Secondary Australian Curriculum for Mathematics and Science has been published, and the Australian Curriculum: Technologies is still under development. Negotiations with the states and territories are progressing to determine the extent to which the curriculum will be implemented. States and territories are responsible for determining senior secondary certification requirements, which mandate which curriculum elements are required for certification purposes.

School student performance (achievement in mathematics and science)

Results emerging from international assessment programs, including the Trends in International Mathematics and Science Study (TIMSS) and Program for International Student Assessment (PISA) suggest that Australia's school student science and mathematics performance is declining in some instances, and remaining static in others. The 2009 PISA results display a decline over time in mathematical literacy and are of particular concern. Thomson et al. (2010) suggest that 'the average mathematical literacy performance of Australia declined significantly (by 10 score points) between PISA 2003 and PISA 2009, while there was no significant change in the OECD average over this time' (p. vii[4]).

In terms of variations in performance in PISA, there is significant disparity between the states and territories, with students in Western Australia and the Australian Capital Territory achieving the highest raw mean scores, and students in Tasmania and the Northern Territory recording the lowest raw mean scores with respect to mathematics literacy achievement. Males on average scored significantly higher than females, and non-Indigenous students on average scored significantly higher than Indigenous students, by 76 points, or equivalent to almost two years of schooling (*ibid*., p. viii). There were no

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[2] OECD 2012, *Education at a Glance 2012; OECD Indicators*, OECD Publishing, Paris.

[3] Australian Curriculum, Assessment and Reporting Authority 2012, *Australian Curriculum Implementation Survey*, ACARA, Sydney, viewed 11 January 2013, http://www.acara.edu.au/curriculum_1/learning_areas/mathematics.html.

[4] Thomson, S, De Bortoli, L, Nicholas, M, Hillman, K & Buckley, S 2010, *Challenges for Australian education: results from PISA 2009 : the PISA 2009 assessment of students' reading, mathematical and scientific literacy*, viewed 11 January 2013, http://research.acer.edu.au/ozpisa/9.

statistically significant differences in the average mathematics score by school sector[5]. Students from metropolitan schools significantly outperformed students from provincial and remote schools, and students from high SES backgrounds on average significantly outperformed students from low SES backgrounds. In many instances these disparities were large: 'the performance gap between students of the same age from different backgrounds can be equivalent to up to three years of schooling. This gap places an unacceptable proportion of 15-year-old students at serious risk of not achieving significant levels sufficient for them to effectively participate in the 21st century workforce and to contribute to Australia as productive citizens' (*ibid*. p. xiv). A key concern therefore is Australia's 'long tail' of underperformance, and the ramifications of this for disadvantaged cohorts, particularly students from low SES backgrounds, students located in geographically remote locations, and Indigenous students.

In reflecting on these performance gaps, the *Review of Funding for Schooling* stated that:

> The absolute decline in performance as measured by PISA in reading and mathematical literacy is evident at all levels of achievement. Australia's weak performance in reading and mathematics compared to Canada (a similar country) and Singapore (our nearest Asian neighbour participating in PISA) illustrates a serious cause for concern and suggests significant educational reform is needed to address the competitive disadvantage our children face (Gonski et al, op cit, p. 211).

Australia's national student performance assessment regimes, including the National Assessment Program – Literacy and Numeracy (NAPLAN) and National Assessment Program – Scientific Literacy (NAP-SL) confirm this assessment.

School student participation in mathematics and science

In 2009, 133,936 (65 per cent of the total cohort of 206,526) of all Year 12 students were enrolled in science subjects, including biology (49,681 or 24.1 per cent of the total Year 12 cohort), chemistry (35,867 or 17.4 per cent) and physics (29,532 or 14.3 per cent). Geology and earth science enrolled the lowest proportion of Year 12 students (2,201 or 1.1 per cent) (possibly as this is not offered in many schools). In comparison, 148,097 (72 per cent of the total cohort) of all Year 12 students were enrolled in mathematics (National Schools Statistics Collection, ABS cited in Office of the Chief Scientist, 2012, *op cit*., p. 24). The majority of these enrolments were in elementary mathematics, rather than advanced mathematics (10.1 per cent) and intermediate mathematics (19.6 per cent) (Barrington, 2011[6]).

The period 1992 – 2010 saw a decline in Year 12 school science and mathematics participation rates, including a marginal decline in mathematics (from 76.6 per cent to 71.6 per cent), a larger decline in both biology (from 35.3 per cent to 24 per cent) and physics (from 20.8 per cent to 14.2 per cent), and a smaller decline in chemistry (from 22.9 per cent to 17.2 per cent). This decline has been attributed to the increased range of Year 12 course offerings (Lyons and Quinn, 2010), and a decline in the 'perceived utility value' of physics and chemistry, in particular (Office of the Chief Scientist, *op cit.,* p. 53).

In terms of mathematics specifically, the National Committee for the Mathematical Sciences (2006) reported that the spread of achievement in years leading up to Year 12 is wide and growing, with 'extensive underachievement and small numbers reaching

[5] Students from independent schools achieved significantly higher average raw scores than students from Catholic and government schools, and students from Catholic schools significantly outperformed those in government schools. However, once differences in students' SES backgrounds were taken into account, these differences were not statistically significant.

[6] Barrington, F 2011, *AMSI Interim Update on Year 12 Mathematics Student Numbers*, 2011, Australian Mathematical Sciences Institute.

advanced levels' (cited in Broadbridge and Henderson, 2008[7], p. 17). This reduces the number of students eligible to progress to advanced school-level mathematics. In terms of Year 12 mathematics, for the period 1995-2010, participation in elementary mathematics increased (from 37 per cent to 50 per cent), while participation in both intermediate and advanced mathematics decreased (from 27.2 – 19.6 per cent and 14.1 – 10.1 per cent respectively) (AMSI, 2012[8]). Intermediate and advanced mathematics (calculus-based subjects) are prerequisites for many university STEM-discipline courses, so decreased cohorts in these subjects in Year 12 have implications for the pipeline to university STEM-disciplines.

In NSW, Mack and Walsh (2013)[9] found 'a substantial decline in the proportion of students undertaking at least one maths and one science subject in the HSC. In 2001 some 19.7% of boys and 16.8% of girls from the corresponding Year 8 cohort went on to study a maths/science combination in the HSC. However, in 2011 only 18.6% of boys and 13.8% of girls went on to study maths/science in the HSC' (p. 1). It should be noted the cohort size has increased in this period. Furthermore, the report notes the high proportions of high achieving (ATAR-eligible) students who do not participate in any mathematics programs in Year 12, particularly girls. In particular, the declining proportion of girls studying maths/science combinations in the senior secondary certificate is worrying due to the potential narrowing of subsequent study and career pathways, particularly in relation to STEM-discipline degrees.

In terms of post-school pathways, research regarding transitions to STEM occupations from Year 12 science and mathematics (Anlezark et al., 2008[10]) suggests that attention needs to be given to the transitions for young males into STEM occupations following STEM study, whereas attention should be focused on transitions for young females into post-school STEM study following Year 12 science and mathematics study.

VET and university student participation in STEM disciplines

In 2010, the Vocational Education and Training (VET) sector catered for 1,799,000 students (655,800 effective full time students), enrolled in courses in dual-sector universities (8.2 per cent of the total), TAFE institutes (70.8 per cent), public universities (0.3 per cent) and other training providers (20.7 per cent). The higher education sector catered for 1,192,700 students (861,500 EFT), enrolled through dual-sector universities (10.1 per cent of the total), TAFE institutes (0.3 per cent), public universities (83.2 per cent) and other training providers (6.4 per cent).

In 2010, the Vocational Education and Training sector enrolled students in programs spanning Australian Qualification Framework (AQF) levels 1-8 (Certificate 1 – Graduate Certificate or Graduate Diploma) and non-AQF programs. Moreover the higher education sector enrolled students in programs spanning AQF levels 5 – 10 (Diploma – Doctoral degree)[11]. In terms of AQF programs, the majority of VET students enrolled in Certificate Level III programs (34.3 per cent), whereas the majority of higher education students enrolled in Bachelor degree (Pass and Honours) programs (73.6 per cent).

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7 Broadbridge, P & Henderson, S 2008, *Mathematics Education for 21st Century Engineering Students,* Australian Mathematical Sciences Institute, Melbourne, viewed 26 February 2013, http://scholar.google.com.au/scholar?cluster=18143973785765796401&hl=en&as_sdt=0,5&as_vis=1.

8 Australian Mathematical Sciences Institute 2012, *Discipline Profile of the Mathematical Sciences*, AMSI, Melbourne.

9 Mack, J. & Walsh, B. 2013. *Mathematics and science combinations NSW HSW 2001-2011 by gender.*

10 Anlezark, A, Lim, P, Semo, R & Nguyen, N 2008, *From STEM to leaf: Where are Australia's science, mathematics, engineering and technology (STEM) students heading?* NCVER, viewed 25 February 2013, http://www.innovation.gov.au/Skills/ResourcesAndPublications/Documents/STEMtoLeafAustSciTechEnginMathHeading.pdf.

11 Office of the Australian Qualifications Framework Council 2012, *AQF Qualifications*, viewed 18 February 2013, http://www.aqf.edu.au/AbouttheAQF/AQFQualifications/tabid/98/Default.aspx.

In terms of field of education, 195,000 effective full time VET students were enrolled in STEM disciplines (Natural and Physical Sciences, Information Technology, Engineering and Related Technologies, Agriculture Environmental and Related Studies), representing 29.9 per cent of all VET EFT enrolments. Over half of these enrolments were in the Engineering and related technologies field of education. 349,000 EFT higher education students were enrolled in STEM disciplines, representing 32.7 per cent of all higher education enrolments. Over a third of these enrolments were in the Health field of education. In total, 496,300 EFT VET and higher education students were enrolled in STEM disciplines in 2010, representing a total of 32.7 per cent of all enrolments.

In terms of gender representation, while more females enrolled in VET (322,700) than males (331,800) in 2010, many more males than females enrolled in STEM disciplines (44,300 males versus 14,700 females). Similarly in the higher education sector, more females were enrolled overall than males (477,600 versus 383,900), however females were under-represented in STEM disciplines in the higher education sector (40,100 males versus 31,000 females). The inclusion of the Health field of education, which enrols 19,100 females, decreases the gender disparity in STEM disciplines considerably. The greatest disparities in higher education STEM discipline enrolments are notable in Information Technology (7,200 males versus 1,300 females) and Engineering (14,300 versus 2,300).

For the period 2002-2010, commencing undergraduate and higher degree by research enrolments increased only marginally in several STEM-related disciplines (Natural and Physical Sciences and Engineering marginally increased; Agriculture, Environmental and Related Studies fluctuated but remained relatively static overall). Enrolments in Information Technology decreased and enrolments in Health increased significantly. The number of STEM course completions declined between 2007 and 2009, and then began to recover. In 2011 the number of completions in STEM disciplines (22,400) exceeded the number in 2007 for the first time. Engineering and Related Technologies completions have been the most resilient, rising year-on-year, in contrast to reductions in numbers for other STEM fields, particularly Information Technology. Women remain significantly under-represented in Engineering and Related Technologies, and Information Technology (Dobson, 2012[12]).

While average admission scores for Information Technology have declined significantly (from median = 86 in 2001, to 78 in 2006), Australian Tertiary Admission Rank (ATAR) scores for Natural and Physical Sciences (median = 87; 2001-2006) and Engineering (median = 90-89; 2001-2006) have remained relatively high (Ainley et al., 2008[13]).

[12] Dobson, I 2012, *Unhealthy Science? University Natural and Physical Sciences 2002 to 2009/10*, report commissioned for the Office of the Chief Scientist, viewed 11 January 2013, http://www.chiefscientist.gov.au/wp-content/uploads/Unhealthy-Science-Report-Ian-R-Dobson.pdf.

[13] Ainley, J, Kos, J & Nicholas, M 2008, *Participation in Science, Mathematics and Technology in Australian Education*, ACER, viewed 26 February 2013, http://research.acer.edu.au/cgi/viewcontent.cgi?article=1003&context=acer_monographs&sei-redir=1&referer=http%3A%2F%2Fscholar.google.com.au%2Fscholar%3Fhl%3Den%26q%3Daverage%2Badmission%2Bscore%2Bnatural%2Band%2Bphysical%2Bscience%2Bcourses%2Bmathematics%2Bsciences%26btnG%3D%26as_sdt%3D1%252C5%26as_sdtp%3D#search=%22average%20admission%20score%20natural%20physical%20science%20courses%20mathematics%20sciences%22.

Minority groups

Disparities persist between states and territories; between government, Catholic and independent schools. These affect particular student cohorts: Indigenous, students with disability, students in remote and very remote locations, students from low socio-economic status (SES) backgrounds. Where these disadvantages compound, particularly for Indigenous students living in remote and very remote locations, young Australians are at particular risk. Disparities are evidenced by the NAPLAN, NAP-SL, PISA and TIMSS results. With respect to participation in university education, students from low SES backgrounds and rural and remote locations are under-represented in the general student population; and women are under-represented in the STEM fields of education of Engineering and Information Technology. These disparities are longstanding.

Adult educational achievement

The upper secondary graduation rate for Australians under the age of 25 is higher in general programs (70 per cent versus 49 per cent) and lower in pre-vocational and vocational programs (23 per cent versus 35 per cent) compared to the OECD norms (OECD, 2012[14]). These rates should be interpreted carefully as they represent the estimated percentage of people from a certain age cohort that is expected to graduate at some point during their lifetime and is sensitive to changes in the duration of the programs.

The Standing Council on Tertiary Education Skills & Employment (SCOTESE) reported in *National Foundation Skills Strategy for Adults* (2012) that '44% of Australia's working age population (around 6 million people) have literacy levels below … the level needed to meet the complex demands of work and life in modern economies. This equates to 40% of employed Australians, 60% of unemployed Australians and 70% of those outside the labour force. … (which) lend(s) weight to concerns about our ability to meet projected skills demands in coming years' (p. 2)[15]. These suggest extremely serious concerns about the scientific literacy of large numbers of the Australian population.

Up to 73 per cent of the Australian population aged 25-64 years had completed at least upper secondary level education or more. This figure is up to 85 per cent among those aged 25-34 years, above the OECD average of 82% for this group. As many as 27 per cent of Australians aged 25-64 years have attained tertiary type A (bachelor or other undergraduate level program) and advanced research programs, above the OECD average of 22 per cent. Among Australians aged 25-34 years, 34 per cent had attained up to bachelor or advanced research programs in 2010.

Teacher supply

Australia's schools are staffed by over 300,000 teachers. The *Staff in Australia's Schools* (SiAS) survey identified a small number of unfilled specialist area teaching positions including science (10 positions overall), computing (110) and technology (70), in almost all cases at a rate of one position unfilled per school, where a vacancy was identified. There were no reported unfilled numeracy positions (McKenzie et al, 2011[16]), however there was a sizable number of unfilled Generalist Primary teacher positions (610) at the time of the survey (Staff in Australia's Schools [SiAS] survey, p. 108)[17]. The Department of Education,

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14 OECD 2012, *Education at a Glance 2012; OECD Indicators*, OECD Publishing, Paris.

15 SCOTESE 2012, *National Foundation Skills Strategy for Adults*, Australian Government, Canberra.

16 McKenzie, P, Rowley, G, Weldon, P & Murphy, M 2011, *Staff in Australia's Schools 2010: Main Report of the Survey*, Australian Council for Educational Research, Melbourne.

17 Department of Education, Employment and Workplace Relations 2012, *Staff in Australia's School (SiAS) Survey*, viewed 7 January 2013, http://foi.deewr.gov.au/node/25764.

Employment and Workplace Relations aggregated *Skills Shortage List Australia 2011-12* (current as at June, 2012) identified national skills shortages for the education professionals classification of Early Childhood (Pre-primary School) Teacher (DEEWR, 2012a[18]), and DEEWR does concede that 'secondary school teacher positions in the fields of senior mathematics and science attract relatively few suitable applicants' (p. 23). There is also variation at the state and territory level: recruitment difficulties have been recorded in New South Wales for secondary school teachers in some locations (DEEWR, 2012b[19]), Queensland for primary school teachers in regional areas (DEEWR, 2012c[20]), Tasmania for mathematics and science teachers (DEEWR, 2012d[21]) and the Northern Territory for primary school and secondary school in mathematics and IT, particularly in remote locations (DEEWR, 2012e[22]). Schools located in regional and remote areas, or Indigenous communities, and schools with a low socioeconomic advantage experience more difficulty filling teaching vacancies (DEEWR, 2012f).

In addition to the question of shortages, serious concerns exist with respect to primary school teacher's level of science and mathematics training, and confidence and capacity to deliver lessons in this area. The Australian Mathematical Sciences Institute has called on the government to ensure teachers are 'mathematically prepared', and has indicated that 'a concerted and immediate effort by governments, the teaching profession and the universities is required to guarantee the supply of suitably qualified mathematics teachers' (2012, n.p.[23]).

Secondary school principals identified larger numbers of unfilled teaching positions including 400 in mathematics (390 positions in mathematics; 10 in statistics), 190 in science (chemistry – 80; physics – 50; science: general – 50 and biology – 10) and 310 in technology (computing – 30; information technology – 130; and wood or metal technology – 120). In many instances individual schools reported vacancies of more than one unfilled teacher in the nominated specialty, indicating that some secondary schools in particular experience difficulty recruiting teaching staff. In total, there were some 900 unfilled mathematics, science and technology positions identified in 2011 (McKenzie et al, *op cit*.). Teacher skills shortages, particularly with respect to secondary qualified science teachers, have been identified as a key element of the 'crisis in science education' (Tytler, 2007[24]).

Where there are unfilled positions, secondary school principals report the implementation of strategies including 'requiring teachers to teach outside their field of expertise' (42.2 per cent), 'recruit(ing) retired teachers on short-term contracts' (25.1 per cent), and 'recruit(ing) teachers not fully qualified in subject areas with acute shortages' (23.0 per cent). Again there were variations between school systems with more secondary school principals from government (72.9 per cent) than Catholic (67 per cent) or independent schools (49.3 per cent) resorting to a range of strategies to deal with staffing shortages (McKenzie et al, *op cit.*). As such, where there are labour market shortages in specialist science, mathematics and technology secondary school teaching positions, government and catholic schools in particular are resorting to sourcing under-qualified, or indeed unqualified replacement staff. The Australian Mathematical Sciences Institute suggests that 'the ageing secondary

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18 Department of Education, Employment and Workplace Relations 2012a, *Skills Shortage List Australia,* DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

19 Department of Education, Employment and Workplace Relations 2012b, *Skills Shortages New South Wales,* DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

20 Department of Education, Employment and Workplace Relations 2012c, *Skills Shortages Queensland*, DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

21 Department of Education, Employment and Workplace Relations 2012d, *Skills Shortages Tasmania*, DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

22 Department of Education, Employment and Workplace Relations 2012e, *Skills Shortages Northern Territory*, DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

23 Australian Mathematical Sciences Institute 2012, *Forum Communique* (press release), AMSI, Canberra.

24 Tytler, R 2007, *Re-imaging Science Education Engaging students in science for Australia's future*, Australian Education Review, Australian Council for Educational Research (ACER) Press, Victoria.

teacher population and falling graduation rates indicate an endemic problem' (AMSI, *op cit.,* p. 2).

In terms of qualifications, only 61.5 per cent of mathematics Year 7/8-10 teachers had two or more years' tertiary training in mathematics (the minimum required to teach mathematics subjects in most countries). This indicates that a large proportion of junior secondary mathematics teachers (38.5 per cent) teach out of field (that is, they have less than two years tertiary training in mathematics). This is a serious concern.

STEM labour market

Australia's STEM-related workplace totals approximately 627,000, including Health (338,000), ICT (144,000), Engineering (79,000) and Natural and Physical Sciences (66,500). Doctorate holders in the STEM-related workforce are concentrated in Natural and Physical Sciences and Health. In addition to STEM-specific employees, many university graduates holding STEM-related qualifications are employed in non-STEM related fields. National STEM-related skills shortages have been identified for Design, Engineering, Science and Transport Professionals, Health Professionals and Engineering, ICT and Science Technician positions. Engineering-related skills shortages have largely been attributed to activity in the resources and infrastructure construction sectors. In some instances, strategies involving a combination of Australian and global immigration are in place to fill STEM-related vacancies.

There are also concerns regarding the Australian university academic staffing profile as the academic workforce ages, the proportion of tenured staff positions decrease, casualisation increases, employment conditions exacerbate recruitment difficulties, and global competition and mobility increases. These concerns reflect the capacity of the university sector to enhance scientific literacy in the general student population, educate STEM undergraduate and higher degree by research students, and undertake research in STEM disciplines.

Policies, strategies and programs

Commonwealth government reports and policy statements have specifically focused on elements of the education, and science and innovation agendas relevant to science, technology, engineering and mathematics. With respect to schooling and teaching quality, the *Melbourne Declaration on Educational Goals for Young Australians* commits all Australian governments to quality schooling, including knowledge in mathematics and science (physics, chemistry and biology). The *Measurement Framework for Schooling in Australia*, NAPLAN, NAP-SL and NAP-ICT package provides a framework for the collection of data regarding mathematical and science performance, scientific literacy and ICT literacy. These Australian assessment regimes are additional to the PISA and TIMSS initiatives.

There have been a number of inquiries into teaching and teacher education. The Council of Australian Government (COAG) *National Partnership Agreement on Improving Teacher Quality* supported the development of the *Australian Professional Standards for Teachers* by the Australian Institute for Teaching and School Leadership (AITSL), national accreditation of pre-service teacher training courses, national consistency in graduate teacher registration (AITSL Proficient Standards), performance management systems and professional development. In response to the *Review of Funding for Schooling: Final Report* the Australian government has announced the *National Plan for School Improvement.* A key theme of the plan is Quality Teaching, which involves reforms aimed at ensuring Australia has the best possible teachers and that they are adequately supported. Announced reforms include: increasing entry requirements for school leavers and mature-aged teaching degree applicants; increasing the length of teacher education practicum requirements; improvements to teacher performance management; higher quality professional development and greater school autonomy with respect to staff selection and employment.

Government reviews have recognised the issues facing declining student engagement with, and participation in, school science and mathematics, and recommended a range of policy interventions to address declining performance and general scientific literacy. This includes improving primary school science through literacy education, establishing partnerships between industry and education, installing contemporary science equipment, and providing careers education and transition support. In terms of participation in higher education, reviews have recommended strategies to address disparities faced by particular cohorts; for example the Bradley review's targets for increasing participation of students from low SES backgrounds. The Cutler review made recommendations relevant to STEM research and development and industry innovation. With respect to both school and university education, addressing the inequities for Indigenous Australians is a key government priority. The COAG *National Foundation Skills Strategy for Adults* highlights skill development needs for adults, including the skills of English language, literacy and numeracy which are seen as precursors for scientific literacy. The Australian Workforce and Productivity Agency is exploring a range of strategies to increase the skill level of Australia's workforce, including scientific literacy and capacity to transition to higher education.

Commonwealth, state and territory governments have produced a number of policies, strategies and review reports related, directly and indirectly, to STEM. This includes documentation focused on early childhood and school education, vocational education and training, existing workforce skills development, research and development, and innovation. Policy interventions to support STEM and scientific literacy address teaching, curriculum, curriculum resources, school and university education and research infrastructure, work integrated learning (for example internships and workplacements), career and subject selection advice, post-school transitions, cross-sectoral partnerships (education, industry, government) including the *School Business Community Partnership Brokers Program*, existing workforce development, targeted immigration, research capabilities, business development, commercialisation, community engagement and accountability.

Conclusion

Despite the plethora of government policies and reviews focused on school education, and science and innovation and the recent emergence of the STEM agenda in Australia, there is currently no Commonwealth *'Science, Technology, Engineering and Mathematics (STEM) Policy'*. Furthermore, in the policy documentation examined there appears to be only limited coherence between Commonwealth policy interventions and state and territory policies and programs other than where COAG national agreements are in place. As expected, there is great variation between state and territory approaches to STEM-specific and/or education, skills development and R&D policies, reflecting differing priorities, contexts and requirements. However, the policy documentation examined suggests a dislocation between national agendas concerning key STEM-related initiatives, such as implementation of the Australian Curriculum and Australian Professional Standards for Teachers.

The 'pipeline' is decreasing. Participation in senior secondary school science is decreasing in each of the enabling sciences - biology, chemistry and physics. Participation in senior secondary school mathematics is decreasing, alongside a trend towards easier mathematics courses. Whilst universities have manipulated pre-requisites to attract high achieving students and provide increased access to disadvantaged cohorts, there is a point at which reduced foundational knowledge in the enabling sciences and mathematics limits study and career prospects. Participation in university undergraduate and higher degree by research programs in STEM-disciplines is only marginally increasing, due largely to the significant increases in Health which have masked persistent declines in Information Technology, and only marginal increases in Engineering and Natural and Physical Sciences. Whilst a significant proportion of vocational education and training (VET) sector students participate in STEM-disciplines, most enrol in low AQF-level courses, thereby forestalling their participation in high-end STEM occupations. Despite more women than men participating in both the vocational education and training (VET) sector and higher education generally, there remains a persistent gender disparity in many STEM-disciplines, principally including Information Technology and Engineering.

Performance in school-level science is fluctuating. It is certainly not improving to the extent that our international comparators and neighbours are. Performance in school-level mathematics is declining, whilst that of several of our international comparators and neighbours is increasing. There are persistent discrepancies in student performance between the states and territories, with students in the Australian Capital Territory consistently recording the highest achievement, and students in the Northern Territory the lowest. The gap is wide. The long tail of underperformance in science, mathematics, scientific literacy, and literacy and numeracy more generally for several cohorts, particularly Indigenous students, students in remote and very remote locations and students with disability, is of great concern.

Whilst it would appear that the ‘crisis’ with respect to teacher supply has diminished somewhat, the limited data on graduating teacher numbers and teacher shortages makes assertions regarding teacher supply problematic. The professional associations maintain that shortages are endemic. However what is clear is that there are large numbers of secondary teachers teaching mathematics out of field, and there are serious questions regarding arrangements whereby primary teachers without discipline-specific training are required to deliver primary school level science and mathematics curriculum without sufficient support and professional development.

There are challenges facing Australia’s research and development and innovation sector; there have been repeated calls for further funding injections. There appear to be national labour market shortages in some STEM-occupations, most notably engineering. The skill levels of a large proportion of the existing workforce and the unemployed in terms of literacy and numeracy are alarming. Australia’s comprehensive performance monitoring systems, particularly for school-level education, now provide a graphic illustration of the nature and depth of these concerns.

Where the Commonwealth government agrees to embrace the STEM agenda, a coherent ‘Science, Technology, Engineering and Mathematics (STEM) Policy’ spanning all Commonwealth, state and territory governments, education systems and industry, including strategies pitched at early childhood, school, VET, higher education and research and development for students, adults and business could go some way to addressing these challenges.

INTRODUCTION

This report has been prepared for the Securing Australia's Future / Australian Council of Learned Academies (SAF/ACOLA) STEM: Country Comparisons Project. The report examines community attitudes to STEM, school student participation and performance in the enabling sciences and mathematics, vocational education and training (VET) and university student participation in STEM-disciplines, and STEM labour market shortages. The report provides a snapshot of Commonwealth, state and territory policy interventions to support science, technology, engineering and mathematics (STEM) through initiatives focused on schools, teaching quality, universities, the existing workforce, and science and innovation. The report does not examine issues regarding student engagement, identity or pedagogy, as these are addressed in Tytler et al, *Opening up pathways: Engagement in STEM across the Primary-Secondary school transition* (2008), nor does the report examine familial attitudes towards education generally (for example, the phenomenon of 'helicopter' parents[25]), nor science and mathematics specifically.

ATTITUDES TO SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM)

GOVERNMENT ATTITUDES

Commonwealth government

The Commonwealth government has clearly identified school education, and science[26] and innovation[27] as national priorities. Government policy statements, commissioned reviews and responsibilities allocated to government authorities evidence this commitment. For example, in terms of priorities for school education, the pipeline to STEM, the Commonwealth government's policies conceive human capacity, particularly in science and mathematics, as the driver for Australia's future economic development. In announcing the *National Plan for School Improvement*, the Australian Prime Minister, the Hon. Julia Gillard committed to an ambitious target that 'by 2025, Australia should be ranked as a top 5 country in the world in Reading, Science and Mathematics – and for providing our children with a high-quality and high-equity education system' (Gillard, 2012, n.p.)[28]. Raising student performance involves significantly increasing school student performance in science and mathematics as measured by the Programme for International Student Assessment (PISA). The Prime Minister also clearly positions school-level literacy and numeracy development as the building block for economic development: 'To win the economic race, we must first win the education race. … reading, writing, maths will be the foundation stones, taught, tested, improved' (*ibid.*, n.p.).

In terms of science and innovation priorities for university and industry research and development (R&D), the Commonwealth government's response to the commissioned *Venturous Australia — building strength in innovation* (the Cutler review), *Powering Ideas*

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25 The Age, *A hovering parent arrests growth: study*, 20 January 2013, viewed 20 January 2012, http://www.theage.com.au/national/a-hovering-parent-arrests-growth-study-20130119-2d0p4.html.

26 In at least some instances, the Commonwealth considers that the term 'science' encapsulates mathematics. For example the Productivity Commission's report, *Public Support for Science and Innovation* states that 'Mathematics is not an empirical subject, yet would usually be included as a science because of its requirements for internal coherence and the usual capacity for demonstration of the validity of its conjectures through proofs. In any case, it is one of the fundamental tools of science' (2007, p. 5).

27 The Productivity Commission's report, *Public Support for Science and Innovation* defines innovation as 'deliberative processes by firms, governments and others that add value to the economy by generating or recognising potentially beneficial knowledge and using such knowledge to improve products, services, processes or organisational forms' (2007, p. 7).

28 Gillard, G 2012, *National Plan for School Improvement,* National Press Club: Canberra, viewed 30 December 2012, http://www.pm.gov.au/press-office/national-plan-school-improvement.

An Innovation Agenda for the 21st Century committed to a ten year innovation-based reform agenda. This strategy is underpinned by recognition that 'investment in science and technology is critical to the growth of knowledge-based economies, and an important indicator of innovation capacity and performance' (Australian Government, 2009[29], p. 3).

In budgetary terms, the Commonwealth government's commitment to mathematics, engineering and science is reflected in recent funding, with $54 million allocated[30] to mathematics, engineering and science in response to the Office of the Chief Scientist's *Mathematics, Engineering and Science in the National Interest* (2012). Overall, the Commonwealth government's contribution to science and innovation is substantial, representing approximately 30 per cent of the total 2008-09 $24.6 billion gross-expenditure on science-related research and development. Total funding for science and innovation was spread across Natural and Physical Sciences - $3.67 billion, Health and Medical Sciences - $3.5 billion, Information Technology - $5 billion and Engineering - $10 billion, and included support for the Commonwealth research organisations - the Australian Institute of Marine Science, ANSTO, CSIRO, DSTO and Geoscience Australia (Office of the Chief Scientist, 2012, p. 8[31]).

Reviews commissioned by the Commonwealth government also affirmed the importance of high level skills and innovation. The *Review of Australian Higher Education Final Report* (the Bradley review) reported that 'As the world becomes more interconnected and global markets for skills and innovation develop even further, it will be crucial for Australia to have enough highly skilled people able to adapt to the uncertainties of a rapidly changing future' (2008, p. xi). The government's response, *Transforming Australia's Higher Education System* (Australian Government, 2009[32]) commits to 'the expansion of a high quality university sector, to educate the graduates needed by an economy based on knowledge, skills and innovation' (p. 5). The *Venturous Australia – building strength in innovation* report confirms the role of human capital in Australia's economic development:

> Knowledge and skill – in modern jargon human capital – is at the heart of the rise of humanity. … High quality human capital is critical to innovation. Equipping our people with the skills to innovate is essential, not only for the generation and application of new knowledge, but also to use and adapt the knowledge produced elsewhere. … Building high quality human capital requires attention at all levels of education: from early childhood education and schooling, through vocational education and training and higher education, and into the workplace (Cutler & Company, 2008, pp. x-xi[33]).

In terms of structural responses, the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) is the peak science advisory committee, chaired by the Prime Minister. PMSEIC is charged with advising the government on 'important issues of science and technology, broadly defined, including issues related to Australia's economy, public good, education, future industries and employment, security, and sustainable development in a modern world' (DIISRTE, 2012)[34]. In announcing PMSEIC membership

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29 Australian Government 2009, *Powering Ideas: An Innovation Agenda for the 21st Century*, viewed 6 January 2013 http://www.innovation.gov.au/Innovation/Policy/Documents/PoweringIdeas.pdf.

30 Chubb, I 2012, *$54 Million Commitment to Mathematics, Engineering and Science* (press release), viewed 6 January 2013 http://www.chiefscientist.gov.au/2012/05/54-million-committment-to-mathematics-engineering-and-science-2/.

31 Office of the Chief Scientist 2012, *Health of Australian Science*, Australian Government, Canberra.

32 Australian Government 2009, *Transforming Australia's Higher Education System*, Australian Government, Canberra, viewed 11 January 2013, http://www.innovation.gov.au/HigherEducation/Documents/TransformingAusHigherED.pdf.

33 Cutler and Company 2008, *Venturous Australia – building strength in innovation*, viewed 6 January 2013, http://www.innovation.gov.au/Innovation/Policy/Documents/NISReport.pdf.

34 Department of Industry, Innovation, Science, Research and Tertiary Education 2012, viewed 30 December 2012, http://www.innovation.gov.au/science/pmseic/Pages/default.aspx.

changes recently, the Prime Minister announced that 'The changes reflect the Gillard Labor Government's confidence in science and innovation as key drivers to improve Australia's living standards, health, productivity and environment' (Gillard, 2012[35]).

The STEM agenda spans two Commonwealth departments: the Department of Education, Employment and Workplace Relations (DEEWR) and the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE). Under section 92 of the Australian Constitution and subsequent legislation regarding territory governments, the states and territories hold responsibility for fundamental components of science, technology, engineering and mathematics – schools, vocational education and training (VET) and universities. The Commonwealth can provide tied grants under section 96 of the Constitution to the states to support education (Keating et al., 2011, p. 9[36]). Most universities, whilst founded in state legislation, receive more government funding from the Commonwealth than from their respective state or territory governments.

The Commonwealth government's responses to STEM are conceived in terms of school and university education, vocational training and skills formation, research and development, innovation and economic development, rather than as a coherent STEM-specific agenda. In some large measure this reflects the Commonwealth's stated prioritisation of education, and science and innovation, the dispersed Commonwealth departmental responsibilities and Australia's federal system.

Australian Chief Scientist

The Australian Chief Scientist, Professor Ian Chubb, is the leading protagonist for science generally, and STEM specifically, to the government and wider community. The Office of the Chief Scientist's report, *Mathematics, Engineering and Science in the National Interest* states that:

> Policies are emerging around the world that focus on STEM and seek to grow the supply of graduates with the skills and knowledge developed through a quality education in the STEM subjects. The reason is straightforward: the world's dependence on knowledge and innovation will grow and not diminish and to be ahead in the race, a community needs the skills to anticipate rather than follow (2012, p. 6[37]).

The Office of the Chief Scientist's pivotal report, *Health of Australian Science*, progressed the STEM agenda in Australia. In releasing the report, the Australian Chief Scientist stated that:

> The report should lead us to a position where any gaps in our capability will be by design and not the unintended consequence of a failure to notice. The Health of Australian Science Report is not a story about rebuilding after a train wreck. We do not have a train wreck. But the Report is a signal: it encourages us to be alert; to be prudent while willing to take bold action when we need to
> (Chubb, Health of Australian Science, 2012[38]).

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[35] Gillard, J 2012, *Revitalised Prime Minister's Science Council* (press release) 20 January 2012, viewed 1 January 2013, http://www.pm.gov.au/press-office/revitalised-prime-ministers-science-council.

[36] Keating, J, Annett, P, Burke, G & Hanlon, C 2011, *Mapping funding and regulatory arrangements across the Commonwealth and state and territories*, report prepared by the University of Melbourne, commissioned by the Victorian Department of Education and Early Childhood Development on behalf of the Ministerial Council for Education, Early Childhood Development and Youth Affairs.

[37] Office of the Chief Scientist 2012, *Mathematics, Engineering and Science in the National Interest*, Australian Government, Canberra.

[38] Office of the Chief Scientist 2012, *Health of Australian Science report* (press release), viewed 8 January 2013, http://www.chiefscientist.gov.au/2012/05/health-of-australian-science-report-2/.

State and territory governments

The Commonwealth government's commitment to education, and science and innovation is complemented by state and territory policies, reports and initiatives. Several states explicitly embrace the STEM agenda; for example, the Victorian Auditor-General's report, *Science and Mathematics Participation Rates and Initiatives* (2012[39]) affirms the importance of STEM:

> The decline in students pursuing STEM subjects, particularly the enabling sciences, raises concern about the future supply of scientists and engineers, and its potential impact on future research, development and innovation capability. Further, all citizens today need scientific and mathematical literacy, which underpins numerous trades and professions, and is needed to understand a range of economic, social and environmental issues (p. vii).

The subsequent government strategy, *Energising Science and Mathematics Education in Victoria Blueprint Implementation Paper* (Department of Education and Early Childhood Development, 2009[40]) affirms support for STEM, stating that 'success in the global workplace will require 21st-century education systems that increase performance in the stem (Science, Technology, Engineering and Mathematics) disciplines' (p. 5). Similarly, the foreword to the Queensland government's discussion paper, *Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland* by the then Premier confirms the importance of STEM to Queensland:

> Science, technology, engineering and mathematics (STEM) education and skills development plays an important role in the Smart State vision
> (Department of Education, Training and the Arts, 2008, n.p.).

In South Australia, the then Minister for Science and Information Economy, the Hon. Jay Weatherill stated in the foreword to the South Australian strategy, *Shaping the Future—STI10: A 10 Year Vision for Sc* that:

> For all South Australians to reap the benefits of our high value emerging industries and the digital economy, it is critical that we all work together to attract and develop a workforce with stronger skills in science, technology, engineering and mathematics (STEM). Our social and economic prosperity depends on our capacity to effectively harness these skills for the future
> (Department of Further Education, Employment, Science and Technology, Science and Innovation Directorate, 2004, p. 3[41]).

Other states and territories have constructed responses around commitments to education, vocational education and training, skills development, research and development and innovation and economic development. This may reflect their prioritisation of these areas over STEM, or may indicate that they are yet to embrace the STEM agenda.

STUDENT ATTITUDES

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[39] Victorian Auditor-General 2012, *Science and Mathematics Participation Rates and Initiatives,* viewed 5 January 2013, http://www.audit.vic.gov.au/publications/20120606-Science-and-Maths/20120606-Science-and-Maths.html.

[40] Department of Education and Early Childhood Development 2009, *Energising Science and Mathematics Education in Victoria Blueprint Implementation Plan*, Victoria, viewed 5 January 2013, http://www.education.vic.gov.au/Documents/about/programs/learningdev/energisingmathscipaper.pdf.

[41] Department of Further Education, Employment, Science and Technology 2004, DFEEST, Adelaide, viewed 1 January 2013, http://www.dfeest.sa.gov.au/Portals/1/Documents/science/STEM_Skills_Strategy_for_South_Australia.pdf.

Trends in International Mathematics and Science Study (TIMSS), Year 4 and Year 8 students

The Trends in International Mathematics and Science Study (TIMSS) examines school student's attitudes towards science and mathematics.

Table 1: Australian students' attitudes and consequent achievement scores in TIMSS international assessment of student achievement (science)

	Science – 4th grade (average science achievement = 516)			
	Australia		International average	
	% of students	Average achievement	% of students	Average achievement
Like science	55	529	53	504
Somewhat like science	31	506	35	469
Do not like science	14	496	12	461
	Science – 8th grade (average science achievement = 516)			
	Australia		**International average**	
	% of students	Average achievement	% of students	Average achievement
Like science	25	559	35	515
Somewhat like science	42	521	44	472
Do not like science	33	490	21	450

Source: Mullis, IVS, Martin, MO, Foy, P & Arora, A 2012 *TIMSS 2011 International Results in Science.* International Association for the Evaluation of Educational Achievement, Boston

Positive attitude and self confidence are both positively correlated with Year 4 and Year 8 science and mathematics achievement as shown in the table above. Australian 4th grade students' average science achievement score is 516, compared to an international average of 500 (Mullis et al, 2012, p. 38[42]). 55 per cent of 4th grade students in Australia like learning science, as a group their average achievement is 529 points. 31 per cent of 4th grade students in Australia somewhat like learning science, as a group their average achievement is 506 points. 14 per cent of 4th grade students in Australia do not like learning science, as a group their average achievement is 496 points (*ibid,* p. 332).

This correlation is repeated for Australian 8th grade students, whose average science achievement score is 516, compared to an international average of 500 (*ibid*, p. 40). 25 per cent of 8th grade students in Australia like learning science, as a group their average achievement is 559 points. 42 per cent of 8th grade students in Australia somewhat like learning science, as a group their average achievement is 521 points. 33 per cent of 8th grade students in Australia do not like learning science, as a group their average achievement is 490 points (*ibid,* p. 335).

Table 2: Australian students' attitudes and consequent achievement scores in TIMSS international assessment of student achievement (mathematics)

	Mathematics – 4th grade

42 Mullis, IVS, Martin, MO, Foy, P & Arora, A 2012, *TIMSS 2011 International Results in Science.* International Association for the Evaluation of Educational Achievement, Boston.

	Australia		International average	
	% of students	Average achievement	% of students	Average achievement
Like mathematics	45	535	48	509
Somewhat like mathematics	33	508	36	478
Do not like mathematics	22	495	16	466
	Mathematics – 8th grade			
	Australia		**International average**	
	% of students	Average achievement	% of students	Average achievement
Like mathematics	16	553	26	504
Somewhat like mathematics	40	520	42	467
Do not like mathematics	45	476	31	443

Source: Mullis, IVS, Martin, MO, Foy, P & Arora, A 2012 *TIMSS 2011 International Results in Mathematics.* International Association for the Evaluation of Educational Achievement, Boston

The patterns revealed for science are also evident with respect to mathematics. Australian 4th grade students' average mathematics achievement score is 516, compared to an international average of 500 (Mullis et al, p. 40[43]). 45 per cent of 4th grade students in Australia like learning mathematics, as a group their average achievement is 535 points. 33 per cent of 4th grade students in Australia somewhat like learning mathematics, as a group their average achievement is 508 points. 22 per cent of 4th grade students in Australia do not like learning mathematics, as a group their average achievement is 495 points (*ibid*, p. 332).

Similarly, Australian 8th grade students' average mathematics achievement score is 516, compared to an international average of 500 (ibid, p. 40). 16 per cent of 8th grade students in Australia like learning mathematics, as a group their average achievement is 553 points. 40 per cent of 8th grade students in Australia somewhat like learning mathematics, as a group their average achievement is 520 points. 45 per cent of 8th grade students in Australia do not like learning mathematics, as a group their average achievement is 476 points (*ibid*, p. 335).

National Assessment Program – Science Literacy (NAP-SL), Year 6 students

Australian Year 6 student's attitudes towards science are assessed through a Student Survey conducted through the National Assessment Program – Science Literacy (NAP-SL). The Student Survey was conducted for the first time in 2009. A large majority of respondents agreed that science is 'finding out about how things work' (96 per cent) and 'doing experiments' (87 per cent). In terms of attitudes to science, a very large majority agreed that science 'will be important when I am at high school' (82 per cent) and 'is important for lots of jobs' (82 per cent). 40 per cent agreed that 'science is too difficult for most people to understand', and only 53 per cent agreed that 'science is an everyday part of my life'. 74 per cent indicated that they would 'like to learn more science at school' (ACARA, 2009[44], p. 71).

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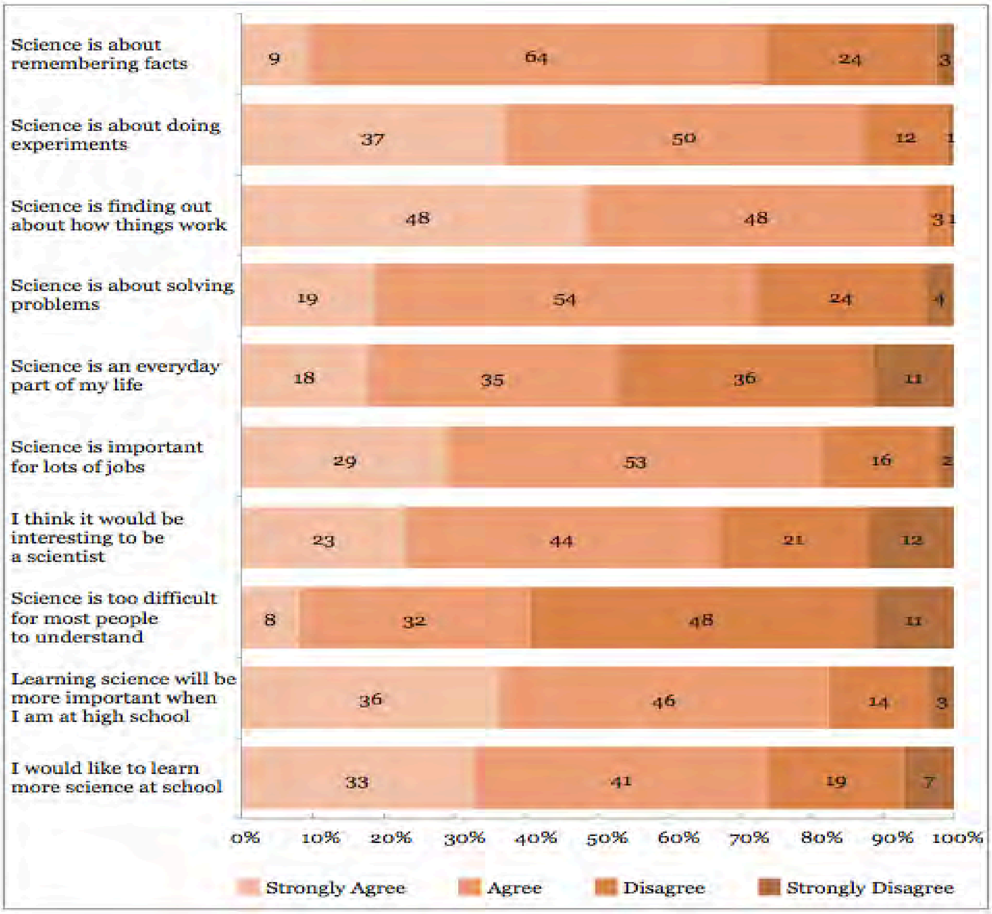
43 Mullis, IVS, Martin, MO, Foy, P & Arora, A 2012, *TIMSS 2011 International Results in Mathematics.* International Association for the Evaluation of Educational Achievement, Boston.

44 Australian Curriculum, Assessment and Reporting Authority 2009, *National Assessment Program – Science Literacy Year 6 Report*, ACARA, Sydney, viewed 1 January 2013, http://www.nap.edu.au/verve/_resources/2009_NAP_SL_Public_report.pdf.

Figure 1: Students' perceptions of and attitudes towards science



Source: ACARA, *National Assessment Program – Science Literacy Year 6 Report*, 2009, p. 71).

Anlezark et al. (2008) found that, for Year 12 students not enrolled in science, mathematics or computing/information technology, 'nothing' would influence their decision to study post-school STEM (equivalent for males and females).

Table 3: Factors which would need to change to consider post-school STEM study by gender (LSAY Y03 students studying in non-STEM study areas)

FACTOR	% WHO MENTIONED (VERBATIM)	
	MALES (N=631)	FEMALES (N=590)
Nothing	60.8	60.3
Better marks	9.1	10.3
More STEM careers information	8.6	6.8
Financial study incentives or future remuneration	4.8	3.4
Improved image of STEM career	2.8	3.2
Better teachers or teaching methods	1.5	2.8

Source: Anlezark, A et al. 2008, *From STEM to leaf: Where are Australia's science, mathematics, engineering and technology (STEM) students heading?* NCVER, p. 27[45].

Smaller proportions of Year 12 students who indicated that they may have been influenced to undertake post-school STEM study nominated potentially influential factors including 'better marks' (9.1 per cent males, 10.3 per cent females), 'more STEM careers information' (8.6 per cent males, 6.8 per cent females) and 'financial study incentives or future remuneration' (4.8 per cent males; 3.4 per cent females).

COMMUNITY ATTITUDES

Community attitudes have been assessed through research commissioned by several state governments. This research has generally found positive community attitudes towards science and technology.

Victorian community attitudes

In 2011, the Victorian Government Department of Business and Innovation commissioned research into the engagement of the Victorian community with science and technology, building on similar research undertaken in 2007. The report revealed positive community attitudes towards science and technology. In particular, there was a high level of interest in science (73 per cent) and technology (86 per cent), triggered by a combination of study, employment and curiosity. In terms of perceived benefits of science and technology, over 80 per cent agreed that scientific research contributes to economic growth; 97 per cent agreed that science and technology improve society; and 93 per cent 'see science resulting in beneficial products, services and other innovations'. A large percentage (86 per cent) disagreed with decreasing Victorian government funding for science to support funding elsewhere (Department of Business and Innovation, 2011, p. 7[46]).

Queensland community attitudes

In Queensland, community attitudes were somewhat mixed; only half of the respondents considered that science and technology would result in increased employment opportunities for the next generation, 65 per cent considered that a scientific career attracted great prestige, and a large percentage (86 per cent) agreed that increased science and technology would increase international competitiveness (Office of Economics and Statistical Research reported in Department of Education, Training and the Arts, 2008, Foreword[47]). As such, there are differences in community attitudes in

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45 Anlezark, A, Lim, P, Semo, R & Nguyen, N 2008, *From STEM to leaf: Where are Australia's science, mathematics, engineering and technology (STEM) students heading?*, NCVER, viewed 25 February 2013, http://www.innovation.gov.au/Skills/ResourcesAndPublications/Documents/STEMtoLeafAustSciTechEnginMathHeading.pdf.

46 Department of Business and Innovation 2011, *Community interest and engagement with science and technology in Victoria,* Government of Victoria, Melbourne, viewed 2 January 2013, http://www.business.vic.gov.au/__data/assets/pdf_file/0018/23832/prtl-sti-ciestv-2011-at-a-glance.pdf.

47 Department of Education, Training and the Arts 2008, *Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland*, DETA, Brisbane.

terms of interest, perceived benefits to the economy and Australian society, and understanding of science employment opportunities.

Australian community attitudes towards biotechnology and nanotechnology

The Commonwealth government conducts a program of research regarding community attitudes to science and technology, including research regarding community perceptions of enabling technologies. In terms of community attitudes to biotechnology, *Public attitudes towards biotechnology in Australia* revealed generally positive community attitudes to biotechnology, other than decreasing support for genetically modified (GM) foods (Department of Innovation, Industry, Science and Research, 2010[48]). In terms of community awareness of biotechnology, the report revealed high levels of awareness of biotechnology applications (higher for medical/health related than food/agriculture related), high levels of perceived utility (approximately two-thirds of respondents), and generally high level of acceptance of biotechnology applications (*ibid.*).

In terms of nanotechnology, the *Final Report Executive Summary Report Australian community attitudes held about nanotechnology Trends 2005 to 2011* reported that awareness of the term 'nanotechnology' had grown in recent years, but knowledge of nanotechnology applications remained low. Perceptions of nanotechnology applications, where known, were generally positive, particularly in terms of health and medical, environmental and protective clothing applications. Perceptions regarding nanotechnology applications for food-related and some skin-applied products were less favorable (Market Attitude Research Services, 2011[49]).

SCHOOLS

SCHOOLS AND STUDENTS

In 2010 there were 9,468 schools in Australia, including 6,357 primary schools, 1,409 secondary schools, 1,286 combined primary and secondary schools and 416 special schools for students with disability. Most government and Catholic schools were primary schools (72 per cent), whereas most independent schools were combined primary and secondary schools (63 per cent) (Gonski et al., 2012[50]).

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48 Department of Innovation, Industry, Science and Research 2010, *Public attitudes towards biotechnology in Australia*, DIISR, Canberra, viewed 7 January 2013, http://www.innovation.gov.au/INDUSTRY/NANOTECHNOLOGY/PUBLICAWARENESSANDENGAGEMENT/Pages/ResearchandReports.aspx.

49 Market Attitude Research Services 2011, *Final Report Executive Summary Report Australian community attitudes held about nanotechnology Trends 2005 to 2011*, viewed 7 January 2013, http://www.innovation.gov.au/Industry/Nanotechnology/PublicAwarenessandEngagement/Documents/NanotechnologyPublicAwareness2011.pdf.

50 Gonski, D, Boston, K, Greiner, K, Lawrence, C, Scales, B & Tannock, P 2011, *Review of Funding for Schooling - Final Report*, Australian Government, Canberra, viewed 28 December 2012, http://foi.deewr.gov.au/node/30439/.

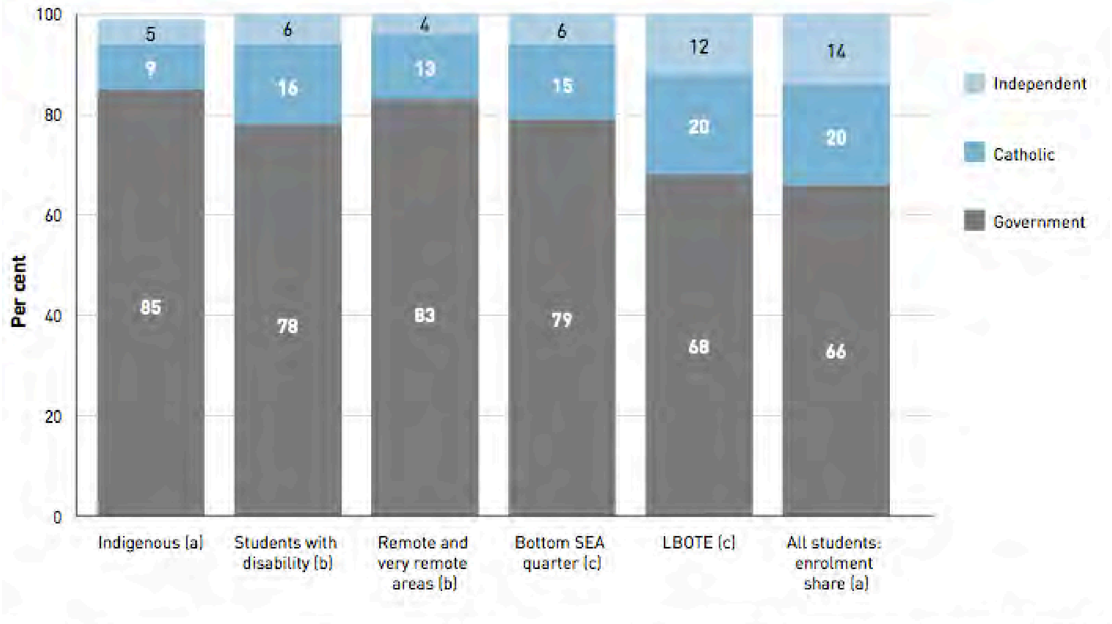
Table 4: Schooling in Australia, 2010

SCHOOLS						
Total number of schools	9,468					
Primary schools	6,357					
Secondary schools	1,409					
Combined schools	1,286					
Special schools (for students with disability)	416					
SCHOOLS BY SECTOR						
Total number of schools	Government 6,743		Catholic 1,708		Independent 1,017	
Primary schools	4,879	72%	1,230	72%	248	24%
Secondary schools	1,034	15%	303	18%	72	7%
Combined schools	498	7%	148	9%	640	63%
Special schools	332	5^	27	2%	57	6%
STUDENTS						
Total number of full-time equivalent students	3.5 million					
Number and percentage attending government schools	2.3 million	66%				
Number and percentage attending Catholic schools	713,289	20%				
Number and percentage attending independent schools	491,233	14%				

Source: Reproduced from ABS 2011c, *Schools, Australia 2010,* cat. No. 4221.0, cited in Gonski et al., *Review of Funding for Schooling – Final Report,* 2012, p. 4.

Australia's schools enrolled 3.5 million full-time equivalent students. The majority of all school students (66 per cent) were enrolled in government schools, with the remainder enrolled in Catholic systemic and non-systemic schools (20 per cent), and independent schools (14 per cent) (*ibid*.). The number of school students has grown over the last decade, with greater growth recorded in the number of independent schools (14 per cent) than Catholic schools (6 per cent) or government schools (2 per cent) (ABS, 2011 cited in Gonski et al., 2012).

Figure 2: Proportion of students by disadvantage group, by sector, 2010



Note: Percentages do not total 100 due to rounding. LBOTE proportions are based on the proportion of students identifying as LBOTE at time of NAPLAN testing.

Source: ABS 2011c, *Schools, Australia, 2010*, cat. No. 4221.0; (b) DEEWR administrative data 2010; (c) ACARA dataset 2011 published in Gonski et al., 2011, p. 10

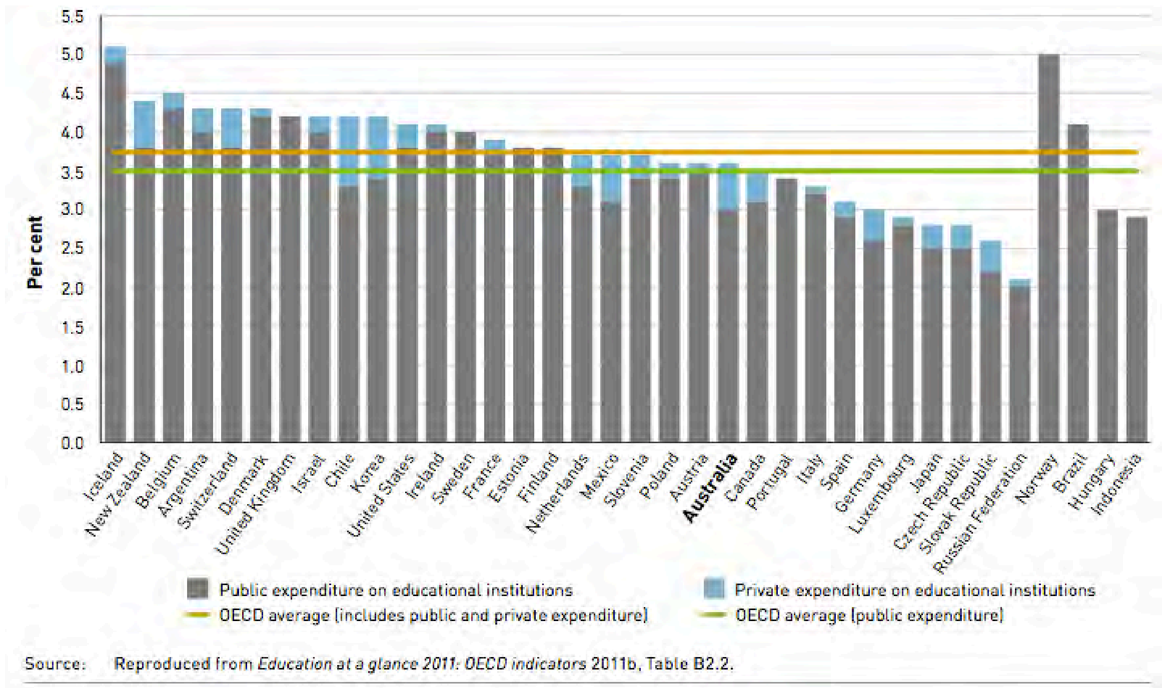
Government schools enrol the majority of disadvantaged students including Indigenous students (85 per cent), students with disability (78 per cent), students located in remote and very remote areas (83 per cent) and students from a low socio-economic status (SES) background (79 per cent). In addition, a large proportion of students from a language background other than English (LBOTE) (68 per cent) are enrolled in government schools.

FUNDING

Funding for Australian schools is shared between the state and territory governments, who hold primary responsibility, and the Commonwealth government. In addition, private funding comprises school fees, philanthropic contributions and revenue generated by fundraising activities. Government funding is made under the *Intergovernmental Agreement on Federal Financial Relations,* supported by National Education Agreements between the Commonwealth, state and territory governments.

The *Review of Funding for Schooling* notes that 'the Australian Government has limited constitutional power in respect of schooling, and the authority it has relates mainly to powers to make grants to the states and territories for schools, provide benefits to students, and regulate corporations' (*op cit*., p. 38). State and territory governments allocate funds to government schools using either a central resource allocation for staff and resources, or a budget allocation for discretionary dispersal (Keating et al. 2011[51], cited in Gonski et al, *op cit.).* State and territory governments allocate funds to independent and Catholic schools on a recurrent and targeted basis. As Keating et al. (2011) note, 'the vast majority of Australian schools have mixtures of state and territory and Commonwealth and private funding. The balance between these three sources varies across and within systems, with government schools receiving the bulk of state government funding, Catholic schools being the main recipients of Commonwealth funding, and independent schools having the highest levels of private revenue although this varies significantly depending on the individual independent school' (*ibid*, p. 6).

Figure 3: Expenditure on primary, secondary and post-secondary non-tertiary education as a percentage of GDP, 2008



Source: Gonski et al., 2011, p. 13

The Organisation for Economic Co-operation and Development (OECD) estimates that Australia's 2009 government expenditure on school and non-tertiary post-school level education (3.8 per cent of GDP) was the same as the OECD country average. Total

[51] Keating, J, Annett, P, Burke, G & Hanlon, C 2011, *Mapping funding and regulatory arrangements across the Commonwealth and state and territories*.

spending on school and non-tertiary post-school education was 4.2 per cent of GDP compared to the OECD country average of 4.0 per cent, reflecting private investment in Australia's relatively large private school sectors.[52] Australia's private expenditure on all educational institutions (primary, secondary and post-secondary non-tertiary education) reflects in part the higher proportion of non-government primary schools than most OECD systems.

CURRICULUM

The *Melbourne Declaration on Educational Goals for Young Australians* (Ministerial Council, 2008) committed to the development of world-class school curriculum. The Australian Curriculum, Assessment and Reporting Authority (ACARA) was given responsibility for developing the Australian Curriculum for Foundation (kindergarten) to Year 12 in specified learning areas. ACARA is developing the Australian Curriculum in phases, with Phase 1 comprising the learning areas of English, science, mathematics and history.

The intention is that Australian Curriculum be implemented in all states and territories, across all school systems (government, Catholic and independent). Implementation will cater for considerable flexibility:

> Jurisdictions, systems and schools will be able to implement the Australian Curriculum in ways that value teachers' professional knowledge, reflect local contexts and take into account individual students' family, cultural and community backgrounds. Schools and teachers determine pedagogical and other delivery considerations
> (ACARA, 2012[53], p. 11)

The Australian Curriculum defines learning areas, specifies general capabilities and establishes cross-curriculum priorities. The Foundation to Year 10 (F-10) Australian Curriculum includes: the learning areas of Mathematics and Science; general capabilities in Numeracy and Information and Communication Technology; and cross-cultural priorities in terms of Aboriginal and Torres Strait Islander histories and cultures, Asia and Australia's engagement with Asia, and Sustainability. Sustainability will cover the organising ideas of Systems, World View and Futures, and be embedded in the various learning areas.

[52] OECD 2012, *Education at a Glance 2012*, p. 245 and p. 269.

[53] Australian Curriculum, Assessment and Reporting Authority 2012, *The Shape of the Australian Curriculum*, ACARA, Sydney, viewed 11 January 2013, http://www.acara.edu.au/curriculum/curriculum_design_and_development.html.

Figure 4: Australian Curriculum, Foundation to Year 10, Phase 1 learning areas

Learning Areas	General Capabilities	Cross-curriculum priorities	Year Level
English	General Capabilities Overview	Cross-curriculum priorities Overview	Foundation
Mathematics	Literacy	Aboriginal and Torres Strait Islander histories and cultures	Year 1
Science	Numeracy	Asia and Australia's engagement with Asia	Year 2
History	Information and Communication Technology (ICT) capability	Sustainability	Year 3
	Critical and creative thinking		Year 4
	Personal and social capability		Year 5
	Ethical behaviour		Year 6
	Intercultural understanding		Year 7
			Year 8
			Year 9
			Year 10
			Year 10A

Source: ACARA 2012, *Welcome to the Foundation to Year 12 Australian Curriculum online* (webpage)[54]

The Senior Secondary Australian Curriculum includes the learning areas of Mathematics (Essential Mathematics, General Mathematics, Mathematical Methods, Specialist Mathematics) and Science (Biology, Chemistry, Physics, and Earth and environmental science). In addition to the mandated Australian Curriculum, schools will provide other programs, including vocational education and training.

Figure 5: Australian Curriculum, Senior Secondary, Phase 1

English	Mathematics
English	Essential Mathematics
English as an Additional Language or Dialect	General Mathematics
Essential English	Mathematical Methods
Literature	Specialist Mathematics

Science	Humanities and Social Sciences
Biology	Ancient History
Chemistry	Modern History
Earth and Environmental Science	
Physics	

Source: ACARA 2012, *Welcome to the Foundation to Year 12 Australian Curriculum online* (webpage)

The Foundation – Year 10 (F-10) Australian Curriculum: Mathematics has been completed. The curriculum includes the following strands: Number and Algebra, Measurement and Geometry, and Statistics and Probability. Proficiency strands include:

[54] Australian Curriculum, Assessment and Reporting Authority 2012, *Welcome to the Foundation to Year 12 Australian Curriculum online* (webpage), viewed 10 January 2013, http://www.australiancurriculum.edu.au/.

Understanding, Fluency, Problem Solving, and Reasoning (ACARA, 2012[55]). The Senior Secondary – Australian Curriculum: Mathematics includes four mathematics courses (Essential Mathematics, General Mathematics, Mathematical Methods and Specialist Mathematics).

The F-10 Australian Curriculum: Science, and Senior Secondary – Australian Curriculum: Science have been completed. F-10 Australian Curriculum has been published, and states and territories have agreed to the phased introduction of this curriculum over the next few years. The F-10 Australian Curriculum: Science includes the following strands: Science Understanding (Biological Sciences, Chemical Sciences, Earth and Space Sciences, Physical Sciences), Science as a Human Endeavour (Nature and Development of Science; Use and Influence of Science) and Science Inquiry Skills (Questioning and Predicting, Planning and Conducting, Processing and Analyzing Data and Information, Evaluating, Communicating). The Senior Secondary – Australian Curriculum: Science includes four subjects (Biology, Chemistry, Earth and Environmental Science, and Physics).

The Australian Curriculum: Science:

> provides opportunities for students to develop an understanding of important science concepts and processes, the practices used to develop scientific knowledge, of science's contribution to our culture and society, and its applications in our lives. It provides an understanding of scientific inquiry methods, a foundation of knowledge across the disciplines of science; and develops an ability to communicate scientific understanding and use evidence to solve problems and make evidence-based decisions. The curriculum supports students to develop the scientific knowledge, understandings and skills to make informed decisions about local, national and global issues and to participate, if they so wish, in science-related careers (ACARA, 2012[56]).

The *Australian Curriculum Implementation Survey* (ACARA, 2012[57]) reports on the state and territory implementation plans to introduce the F-10 Australian Curriculum, noting the phase-in period 2011-2014. The Senior Secondary Australian Curriculum for Mathematics, and Science have both been finalized and published. Negotiations with the states and territories are progressing to determine the extent to which the curriculum will be implemented, and the relationship between the Australian Curriculum and senior secondary certification requirements.

Tytler and Hobbs (2011[58]) have welcomed the inclusion of inquiry-based approaches in the new Australian Curriculum:

> Emphasised is an inquiry-based approach that incorporates exploration, explanation and application in line with constructivist principles of teaching and learning. Context is incorporated as the means by which the curriculum should be made relevant. Open-inquiry opportunities for students at all phases of the curriculum are promoted. Diagnostic, formative, and summative assessment is emphasized, as well as national testing regimes. Teachers are expected to tailor their teaching to the achievement levels of students, and are encouraged to teach across a number of

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[55] Australian Curriculum, Assessment and Reporting Authority 2012, *Mathematics* (webpage), ACARA, Sydney, viewed 11 January 2013, http://www.acara.edu.au/curriculum_1/learning_areas/mathematics.html.

[56] Australian Curriculum, Assessment and Reporting Authority 2012, *Science* (webpage), ACARA, Sydney, viewed 11 January 2013, http://www.acara.edu.au/curriculum_1/learning_areas/science.html.

[57] Australian Curriculum, Assessment and Reporting Authority 2012, *Australian Curriculum Implementation Survey*, ACARA, Sydney, viewed 11 January 2013, http://www.acara.edu.au/curriculum_1/learning_areas/mathematics.html.

[58] Tytler, R & Hobbs, L 2011, The Australian Science Curriculum, *Primary and Middle Years Educator,* 9(2), 3-10.

year levels if needing to differentiate the curriculum to meet the diversity of student achievement levels in their class.

The Australian Curriculum: Technologies is under development.

State and territory senior secondary certification requirements

As noted, states and territories are responsible for determining senior secondary certification requirements, which mandate which curriculum elements and other learning outcomes are required for certification purposes. In terms of *mandatory* requirements for senior secondary certification purposes (in addition to other requirements):

- New South Wales students must complete a Board Developed Course in English to qualify for the Higher School Certificate (HSC)
- Victorian students taking the Victorian Certificate of Education (VCE) must include English units; Victorian students taking the Victorian Certificate of Applied Learning (VCAL) undertake core studies in literacy, numeracy and personal development (along with a VET program and workplacement)
- Queensland students undertaking the Queensland Certificate of Education (QCE) must fulfil literacy and numeracy requirements
- Western Australian students undertaking the Western Australian Certificate of Education (WACE) must meet English language requirements
- South Australian students undertaking the South Australian Certificate of Education (SACE) must complete compulsory requirements in literacy, numeracy and a Research Project[59]
- Tasmanian students undertaking the Tasmanian Certificate of Education (TCE) must meet five standards regarding literacy, numeracy, ICT, participation and achievement
- Australian Capital Territory students undertaking the ACT Year 12 Certificate have no specific mathematics or science requirements
- Northern Territory students undertake an award based on the South Australian Certificate of Education (SACE), and must complete literacy, numeracy and planning requirements (Keating et al., *op cit.*).

As such, at least minimum numeracy requirements for senior secondary certificate purposes are in place for Victorian students doing the VCAL (about 12% of cohort), Queensland students doing the QCE, South Australian students doing the SACE, Tasmanian students doing the TCE, and Northern Territory students doing the SACE. These numeracy requirements do not imply mandatory *mathematics* course participation, nor suggest that participation in at least one Australian Curriculum – Mathematics course will necessarily be a compulsory requirement of the respective senior secondary certificates (assuming at least some states/territories adopt some elements of the senior secondary mathematics curriculum). For example the Tasmanian ‘everyday adult mathematics’ standard currently involves ‘using common maths knowledge and skills to measure, solve basic problems, develop budgets, collect survey information and interpret it, and carry out calculations involving fractions and metric quantities’ (Tasmanian Qualifications Authority, n.d.[60]).

In fact, as illustrated by Coupland (2006), despite the numeracy requirements established in several senior secondary school certificates no states or territories have compulsory mathematics requirements that involve 100 per cent of Year 12 students.

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[59] About the SACE, n.d. viewed 18 February 2013, http://www.sace.sa.edu.au/the-sace/students-families/about-the-sace

[60] Tasmanian Qualifications Authority n.d. *Tasmanian Certificate of Education,* viewed 18 February 2013, http://www.tqa.tas.gov.au/1906#stand.

Indeed Year 12 participation ranges from highest in the Australian Capital Territory (where there are no minimum numeracy standards) and Queensland, and lowest in Tasmania (where there are minimum numeracy standards).

Table 5: State and Territory Populations and Year 12 Enrolments for 2004. Data from Barrington (2006), Tables 2A, 2B, 3A, 3B, 4

	Column A: Number of Students in Year 12	Column B: Number of Students in Advanced Mathematics **(In NSW: Mathematics Extension 1 and possibly Extension 2)** (note 1)	Column C: Students in Intermediate Mathematics but not in Advanced Mathematics **(In NSW: Mathematics)** (note 2)	Column D: Students in Elementary Mathematics Subjects **(In NSW: General Mathematics and Mathematics Life Skills)** (note 3)	Column E: Students not in Mathematics (note 4)
NSW	66279 ***100%***	9959 ***15.0%***	13306 ***20.1%***	30382 ***45.8%***	12632 ***19.1%***
Vic	49975 ***100%***	6293 ***12.6%***	12090 ***24.2%***	22759 ***45.5%***	8833 ***17.7%***
Qld	40592 ***100%***	3430 ***8.4%***	12887 ***31.7%***	21246 ***52.3%***	3029 ***7.5%***
WA	19792 ***100%***	1628 ***8.2%***	2655 ***13.4%***	12785 ***64.6%***	2724 ***13.8%***
SA	13324 ***100%***	1211 ***9.1%***	2134 ***16.0%***	3937 ***29.5%***	6042 ***45.3%***
Tas	4161 ***100%***	228 ***5.5%***	595 ***14.3%***	1340 ***32.2%***	1998 ***48.0%***
ACT	4098 ***100%***	488 ***11.9%***	1148 ***28.0%***	2156 ***52.6%***	306 ***7.5%***
NT	1390 ***100%***	45 ***3.2%***	198 ***14.2%***	543 ***39.1%***	604 ***43.5%***
Totals	199611 ***100%***	23282 ***11.7%***	45013 ***22.6%***	95148 ***47.7%***	36168 ***18.1%***

Source: Coupland, M. 2006[61]

ACCOUNTABILITY

Accountability measures for Australian schools include reporting requirements to the Australian Curriculum, Assessment and Reporting Authority (ACARA). Under the Council of Australian Governments (COAG) *National Education Agreement* NAPLAN results are made publicly available on the *My School* website (www.myschool.edu.au). Government school accountability requirements include the following:

61 Coupland 2006, A critical analysis of selected Australian and international mathematics syllabuses for the post-compulsory years of secondary schooling, viewed 18 February 2013, http://www.boardofstudies.nsw.edu.au/manuals/pdf_doc/maths_st6_lit_curr_rev_pt1.pdf.

- *Strategic/school plans.* These plans have moved from more general statements to more specific goals, including specific measures such as student outcomes and participation patterns;
- *School reports* that are made available to parents or the school council/board/committee. These reports include measures of school performance, and go under various names, including Schools Annual Report (NSW, Qld) School level report (Vic) School Report (WA) and Annual School Board Report (ACT). These reports can be developed by the central agency using the school derived data and including analyses of performance patterns (Vic, Qld). In some systems (WA, Victoria) there are attempts to reduce the burdens upon schools and teachers of reporting to the central agency;
- *Most if not all systems require cycles of school reviews or evaluations.* Typically they include different sequences of school level/self (Vic., SA), negotiated, peer, school evaluations (NSW), and diagnostic (Qld, Vic). For example, WA and ACT schools have a standard review and an experts/external review, and SA schools have a review cycle that can trigger forms of intervention; and
- There is also an emphasis in some systems upon *network based accountability and school improvement* (Vic, WA, NSW). (Keating et al., *op cit.,* p. 30)

PRIMARY SCHOOL STUDENT PERFORMANCE

Trends in International Mathematics and Science Study (TIMSS), Year 4 students

The TIMSS 2011 mathematics results for Year 4 students indicate that Australia was significantly outperformed by 17 other countries (most Asian countries, several Western European countries, England and the United States)[62]. The TIMSS 2011 mathematics Year 4 score (516) was equivalent to the 2007 result, but significantly higher than the 1995 result (495) and 2003 result (499) (Thomson et al., 2012[63], p. 9), which represents an improvement over the period 1995-2011.

The TIMSS 2011 science achievement results for Year 4 students indicate that Australia was significantly outperformed by 18 other countries (most Asian countries, several Western European countries, England and the United States)[64]. The TIMSS science Year 4 score (516) was significantly lower than the 2007 result (527), but was not significantly different to the 1995 and 2003 results (521). Results for Year 4 mathematics and science performance also indicated that Australia had the fifth widest gap of OECD countries between high and low achievers, meaning that Australia's most able students rank among the highest achievers in the OECD while those with poor results rank among the lowest achievers in the OECD. Whilst many countries participating in the TIMSS assessments dramatically improved in science and/or mathematics achievement (the Asian countries of Singapore, Hong Kong and Chinese Taipai) or steadily increased performance (United States, Korea), other than improvement in Year 4 mathematics achievement, Australia's performance stagnated (Masters, 2012[65]).

National Assessment Program – Literacy and Numeracy (NAPLAN), Years 3 and 5 students

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62 Australia's TIMSS Year 4 mathematics score (516) places Australia in the same band as Serbia (516), Hungary (515), Slovenia (513), Czech Republic (511) and Austria (508).

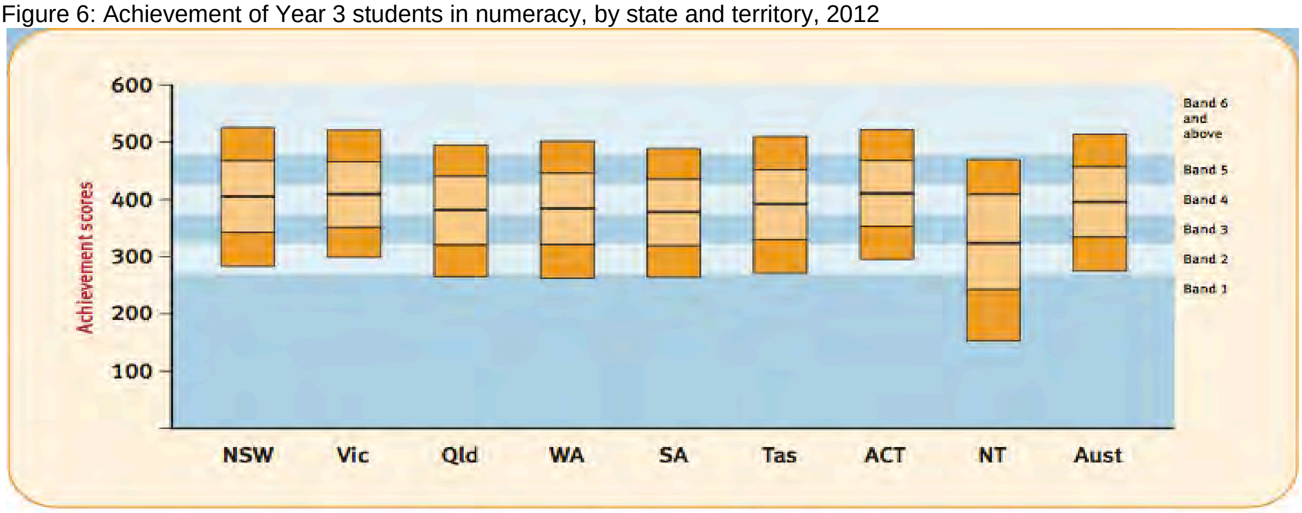
63 Thomson, S, Hillman, K, Wernert, N, Schmid, M & Munene, A, 2012, *Highlights from TIMSS & PIRLS 2011 from Australia's perspective*, ACER, Melbourne, viewed 31 December 2012, http://www.acer.edu.au/documents/TIMSS-PIRLS_Australian-Highlights.pdf.

64 Australia's TIMSS Year 4 science score (516) places Australia in the same band as Portugal (522), Slovenia (520), Northern Ireland (517), Serbia (516), Ireland (516), Croatia (516) and Lithuania (515).

65 Masters, G 2012, *School improvement the key ACER eNews: Latest research results and news from ACER*, ACER, Melbourne, viewed 31 December 2012, http://www.acer.edu.au/enews/2012/12/school-improvement-the-key.

The National Assessment Program is run at the direction of the Standing Council on School Education and Early Childhood (SCSEEC). It includes the National Assessment Program – Literacy and Numeracy (NAPLAN). NAPLAN annually assesses the literacy and numeracy performance of all Australian students in Years 3, 5, 7 and 9. The 2012 NAPLAN results are reported in the *NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy National Report for 2012* (ACARA, 2012[66]). With respect to Year 3 numeracy, differences in student performance were recorded between the states and territories with students in the Australian Capital Territory recording the highest mean scale score (410) and students in the Northern Territory the lowest (323). Overall, 94 per cent of Year 3 students achieved at or above the national minimum standard for numeracy, however there is a long tail of underperformance, most notably in the Northern Territory (for example, 30 per cent of Northern Territory students did not meet the national minimum standard).

Figure 6: Achievement of Year 3 students in numeracy, by state and territory, 2012



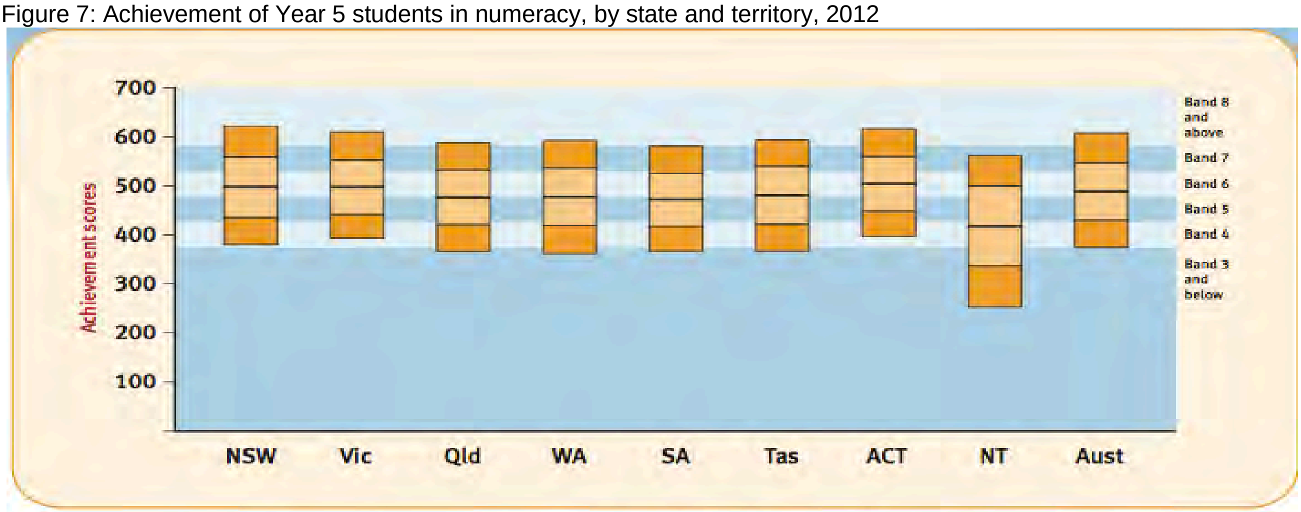
	NSW	Vic	Qld	WA	SA	Tas	ACT	NT	Aust
Mean scale score / (S.D.)	405.0 (73.5)	408.9 (67.6)	380.9 (69.9)	383.9 (72.8)	377.4 (67.9)	391.5 (72.1)	410.1 (68.2)	323.2 (96.6)	395.5 (72.6)

Source: *NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy National Report for 2012* (ACARA, 2012, p. 46)

Female Year 3 students recorded a slightly lower mean scale score than male students (391 compared with 400). Indigenous Year 3 students recorded a significantly lower mean scale score (320 compared with non-Indigenous 400), as did students from remote and very remote locations. Large percentages of Indigenous students in remote and very remote locations did not achieve the national minimum standards for numeracy (41 per cent remote; 62 per cent very remote). Students with a language background other than English (LBOTE) recorded a higher mean scale score than non-LBOTE students (400 compared with 395). Year 3 student performance in numeracy was positively correlated with parental education and occupation (*ibid.).*

66 Australian Curriculum, Assessment and Reporting Authority 2012, *NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy: National Report for 2012,* ACARA, Sydney, viewed 6 January 2013, http://www.nap.edu.au/verve/_resources/NAPLAN_2012_National_Report.pdf.

Figure 7: Achievement of Year 5 students in numeracy, by state and territory, 2012



	NSW	Vic	Qld	WA	SA	Tas	ACT	NT	Aust
Mean scale score / (S.D.)	497.7 (73.5)	497.6 (65.6)	476.1 (66.7)	477.5 (70.3)	471.9 (64.7)	480.4 (69.0)	504.4 (66.6)	417.6 (94.4)	488.7 (70.9)

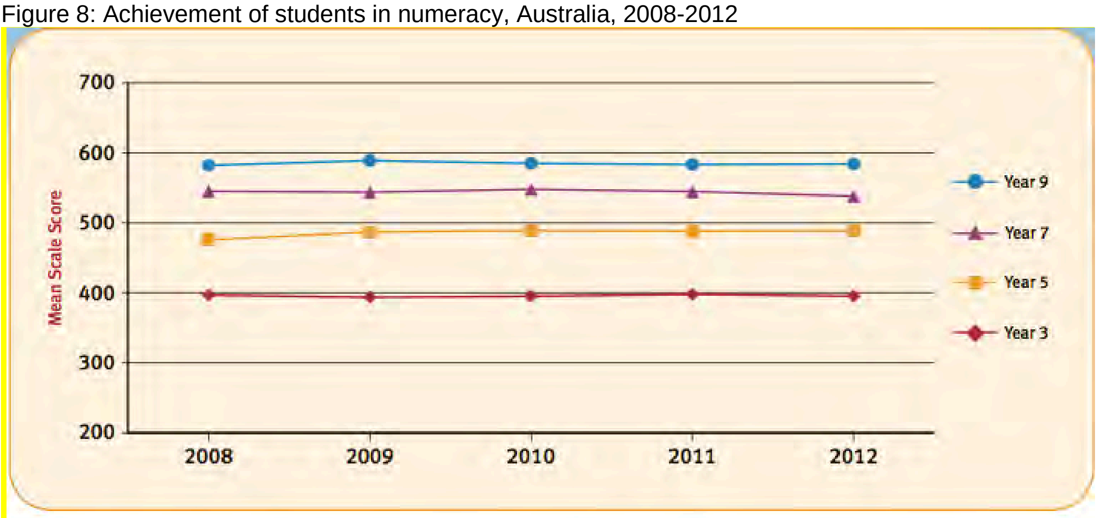
Source: *NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy National Report for 2012* (ACARA, 2012, p. 110)

With respect to Year 5 numeracy performance, differences were again notable between the states and territories with students in the Australian Capital Territory recording the highest mean scale score (504) and students in the Northern Territory the lowest (418). Overall, 93 per cent of Year 5 students achieved at or above the national minimum standard for numeracy. Again, however, there is a long tail of underperformance. Female students achieved slightly lower mean scale scores than males (485 compared with 492), but a higher percentage of female students performed at or above the national minimum standard (94 per cent, compared with 92.6 per cent) (*ibid.*).

Indigenous Year 5 students achieved a significantly lower mean scale score (414) than non-Indigenous students (493), as did students from remote and very remote locations. A large percentage of Indigenous students in remote and very remote locations did not meet the minimum national standards for numeracy (45 per cent remote; 71 per cent very remote)[67]. Students with a language background other than English (LBOTE) recorded a higher mean scale score than non-LBOTE students (494 compared with 488). Student performance was positively correlated with parental education and occupation.

[67] Any changes to these numbers between 2008 and 2012 are not considered statistically significant. The percentages below national minimum standard for Year 5 were: Remote 43.7 in 2008 and 44.7 in 2012; Very remote 67.1 in 2008 and 70.8 in 2012. For the percentages at or above national minimum standard, there was no significant difference between 2008 and 2012.

Figure 8: Achievement of students in numeracy, Australia, 2008-2012



Source: *NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy National Report for 2012* (ACARA, 2012, p. 279)

Over the period 2008-2012, Australian Year 3 and Year 9 student performance in numeracy remained static (397/396; 582/584), Year 5 student performance improved early in this period and then remained static (476/489) and Year 7 student performance decreased marginally (545/538) (*ibid.*). Minor fluctuations were recorded in some jurisdictions. Disparities noted with respect to female students (marginal), Indigenous students (large), and students from remote and very remote locations were consistent over the period 2008-2012.

National Assessment Program – Science Literacy (NAP-SL), Year 6 students

The National Assessment Program also includes sample assessments in scientific literacy, civics and citizenship and Information and Communication Technology (ICT) literacy. The National Assessment Program – Science Literacy (NAP-SL) was first conducted in 2003. The program assesses a sample of Australian Year 6 students on a three yearly cycle. The sample includes approximately five per cent of the Year 6 student population, across all states, territories and school systems (government, independent, Catholic). The NAP-SL has adopted the OECD PISA definition of science literacy:

> … the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity (OECD, 1999, p. 60 cited in ACARA, 2010 p. 3[68]).

The *National Assessment Program – Science Literacy Year 6 Report* (ACARA, *op cit*.) reveals that the mean national Year 6 scientific literacy score for 2009 (392) was lower than that recorded in 2006 (400). However, the report indicates that this decrease was not statistically significant (*ibid.,* p. 29)[69]. There were variations between states and territories with Western Australia recording the largest increase (12) in Year 6 student scientific literacy performance and Tasmania recording the largest decrease (-20). Overall, Year 6 students in the Australian Capital Territory recorded the highest mean score for scientific literacy in 2006 and 2009 (418/415), and the Northern Territory the lowest (325/326).

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[68] Australian Curriculum, Assessment and Reporting Authority 2010, *National Assessment Program – Science Literacy Year 6 Report*, ACARA, Sydney, viewed 6 January 2013, http://www.nap.edu.au/verve/_resources/2009_NAP_SL_Public_report.pdf.

[69] The 2003 mean scores (409) were higher than both the 2006 (400) and 2009 (392) results, however the report noted these for indicative purposes only as 'tests of statistical significance between 2003 and 2009 results were deemed not to be sound' (ACARA, *op cit*., p. 30).

Table 6: Comparison of 2006 and 2009 jurisdiction mean scores ranked by 2009 achievement

STATE/TERRITORY	MEAN SCORE		CHANGE FROM 2006 TO 2009	STATISTICALLY SIGNIFICANT
	2006	2009		
Australian Capital Territory	418	415	-3	No
Victoria	408	398	-10	No
New South Wales	411	396	-15	No
Western Australia	381	393	12	No
Tasmania	406	386	-20	Yes
Queensland	387	385	-2	No
South Australia	392	380	-12	No
Northern Territory	325	326	1	No
Australia	400	392	-8	No

Source: Reproduced from Australian Curriculum, Assessment and Reporting Authority (2010) *National Assessment Program – Science Literacy Year 6 Report*, p. 28.

The disparity between the states and territories was reflected in findings regarding the percentage of students achieving the proficiency level (deemed to be Level 3). Nationally, only nine per cent of Year 6 students did not achieve a proficiency level of Level 3. However, state and territory differences were noted (for example, only 6.3 per cent of Australian Capital Territory students did not achieve this level of proficiency, compared with 31.3 per cent of Northern Territory students). In terms of the national proficient standard (deemed to be Level 3.2), 51.9 per cent of Australian Year 6 students achieved the proficient standard in 2009, compared with 54.3 per cent in 2006, confirming that under-performance is a concern. Small decreases were recorded in all states and territories, but the report indicates that the national and jurisdictional decreases were not statistically significant.

Table 7: Jurisdictions by percentages of students at or above the proficient standard in science literacy in rank order for 2006 and 2009

	2006		2009	
	STATE/TERRITORY	AT OR ABOVE THE PROFICIENT STANDARD	STATE/TERRITORY	AT OR ABOVE THE PROFICIENT STANDARD
1	Australian Capital Territory	62.0	Australian Capital Territory	61.2
2	Victoria	58.3	Victoria	54.6
3	New South Wales	57.4	Western Australia	53.3
4	Tasmania	57.4	New South Wales	53.0
5	South Australia	51.6	Tasmania	49.8
6	Queensland	49.2	Queensland	48.8
7	Western Australia	46.6	South Australia	46.5
8	Northern Territory	38.4	Northern Territory	33.6
	Australia	**54.3**	**Australia**	**51.9**

Source: Reproduced from Australian Curriculum, Assessment and Reporting Authority (2010) *National Assessment Program – Science Literacy Year 6 Report*, p. 57.

Gender and language-background disparities were also recorded, with a slight but not statistically significant difference between Year 6 males (393) and Year 6 females (391), and between Year 6 students with a language background other than English (LBOTE) (384) and English speaking background (ESB) (396) at the national level. The difference between Year 6 Indigenous students and non-Indigenous students in 2009 was large, both in terms of mean scientific literacy score (297/397), and percentage achieving the national proficient standard (19.6/53.9 per cent). In both instances, this represented declines for Indigenous Year 6 scientific literacy student achievement since 2006 (decline from 25.5 to 19.6 per cent) (*ibid*. p. 64). In terms of geographic location of schools, Year 6 students in remote and very remote areas achieved significantly lower levels of scientific literacy than students living in metropolitan or provincial areas (*ibid*.). The 2009 NAP-SL confirms declining levels of scientific literacy amongst Year 6 students, great disparity between the states and territories, and a long tail of under-achievement with large percentages of Year 6 students failing to reach the scientific literacy proficiency standards. The 2009 NAP-SL also confirmed the persistent disparity between Indigenous and non-Indigenous students, students based on geographical location and language background.

SECONDARY SCHOOL STUDENT PARTICIPATION IN SCIENCE AND MATHEMATICS

Participation - Year 12 science and mathematics

In 2009, 133,936 (65 per cent of the total cohort of 206,526) of all Year 12 students were enrolled in science subjects, including biology (49,681 or 24.1 per cent of the total Year 12 cohort), chemistry (35,867 or 17.4 per cent) and physics (29,532 or 14.3 per cent). Geology and earth science enrolled the lowest proportion of Year 12 students (2,201 or 1.1 per cent) (possibly as this is not offered in many schools). 148,097 (72 per cent of the total cohort) of all Year 12 students were enrolled in mathematics (National Schools Statistics Collection, ABS cited in Office of the Chief Scientist, 2012, *op cit*., p. 24). The majority of these enrolments were in elementary mathematics, compared with advanced mathematics (10.1 per cent) and intermediate mathematics (19.6 per cent) (Barrington, 2011[70]).

Table 8: Student enrolments in year 12 science subjects, Australia 2009

SUBJECT	STUDENTS ENROLLED (NUMBER)	PROPORTION OF COHORT (%)
Mathematics	148 097	71.7%
Biology	49 681	24.1%
Chemistry	35 867	17.4%
Physics	29 532	14.3%
Geology and Earth science	2 201	1.1%
Other science	16 655	8.1%

Source: Reproduced from Office of the Chief Scientist (2012) *Health of Australian Science*, p. 24.

The period 1992 – 2010 saw a decline in Year 12 school science and mathematics participation rates, including a marginal decline in mathematics (from 76.6 per cent to 71.6 per cent), a larger decline in both biology (from 35.3 per cent to 24 per cent) and physics (from 20.8 per cent to 14.2 per cent), and a smaller decline in chemistry (from 22.9 per cent to 17.2 per cent). This decline has been attributed to the increased range of Year 12 course offerings (Lyons and Quinn, 2010), and a decline in the ‘perceived utility value’ of physics and chemistry, in particular (Office of the Chief Scientist, *op cit.,* p. 53).

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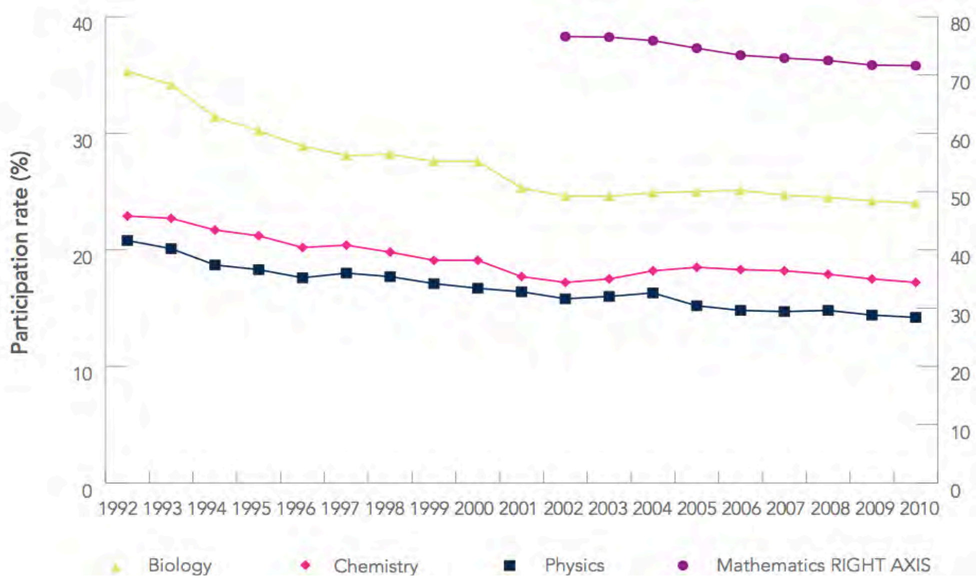
70 Barrington, F 2011, *AMSI Interim Update on Year 12 Mathematics Student Numbers*, 2011, Australian Mathematical Sciences Institute.

Figure 9: Year 12 science participation, Australia, 1992 to 2010



Source: Kennedy [in prep.]; Ainley et al. [2008] reported in Health of Australian Science, 2012, p. 44

In terms of mathematics specifically, the National Committee for the Mathematical Sciences (2006) reported that the spread of achievement in years leading up to Year 12 is wide and growing, with 'extensive underachievement and small numbers reaching advanced levels' (cited in Broadbridge and Henderson, 2008[71], p. 17). This reduces the number of students eligible to progress to advanced school-level mathematics. In terms of Year 12 mathematics, for the period 1995-2010, participation in elementary mathematics increased (from 37 per cent to 50 per cent), while participation in both intermediate and advanced mathematics decreased (from 27.2 – 19.6 per cent and 14.1 – 10.1 per cent respectively) (AMSI, 2012[72]). Intermediate and advanced mathematics (calculus-based subjects) are prerequisites for many university STEM-discipline degrees, so decreases in these subjects have implications for the pipeline to university STEM-disciplines.

PERFORMANCE

TIMSS

The TIMSS 2011 mathematics achievement results for Year 8 students indicate that Australia was significantly outperformed by five Asian countries and the Russian Federation[73], with Australia's TIMSS Year 8 score fluctuating over the period 1995-2011 between 509 (1995), 496 (2007) before increasing again to 505 in 2011. TIMSS 2011 science achievement results for Year 8 students (519) indicate that Australia was significantly outperformed by nine countries including several Asian countries, Finland, Slovenia, the Russian Federation and England[74]. Australia's TIMSS 2011 science achievement Year 8 score over the period 1995-2007 fluctuated between 514 (1995) before increasing to 527 (2003) and then decreasing to 515 (2007). In all tests, there was much variation between the states and territories, with students in the Australian Capital

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[71] Broadbridge, P & Henderson, S 2008, *Mathematics Education for 21st Century Engineering Students,* Australian Mathematical Sciences Institute, Melbourne, viewed 26 February 2013, http://scholar.google.com.au/scholar?cluster=18143973785765796401&hl=en&as_sdt=0,5&as_vis=1.

[72] Australian Mathematical Sciences Institute 2012, *Discipline Profile of the Mathematical Sciences*, AMSI, Melbourne.

[73] Australia's TIMSS Year 8 mathematics score (505) placed Australia in the same band as Israel (516), Finland (514), United States (509), England (507), Hungary (505), Slovenia (505), Lithuania (502) and Italy (498).

[74] Australia's TIMSS Year 8 mathematics score (519) placed Australia in the same band as the United States (525), Hungary (522), Israel (516), Lithuania (514), New Zealand (512) and Sweden (509).

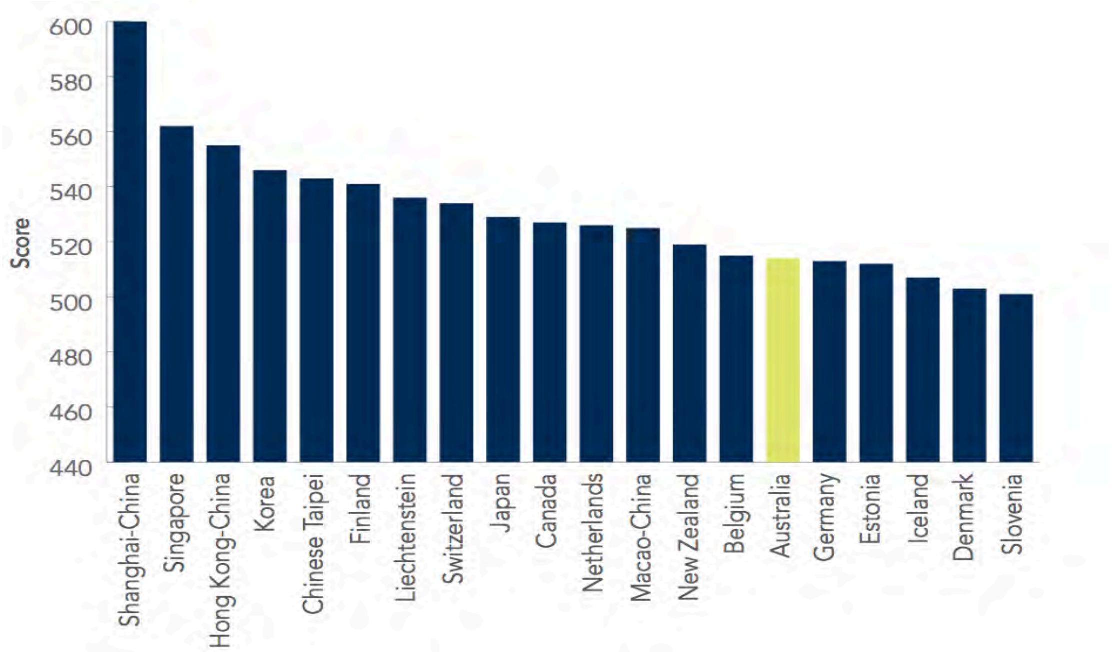
Territory consistently achieving the highest raw mean score and students in the Northern Territory consistently recording the lowest raw mean score (Thomson et al., *op cit*.[75]). These results demonstrate that Australia's Year 8 mathematics and science performance has stagnated (Masters, *op cit*.), whilst other countries have improved over the same period.

PISA

Mathematical literacy, 15 year old students

The Programme for International Student Assessment (PISA) is administered by the OECD. The 2009 PISA results indicate that in terms of mathematical literacy Australian 15-year-olds achieved an average score (514) significantly higher than the OECD average (496). This 2009 PISA result places Australian students at equal 13th, being significantly outperformed by Shanghai-China, Singapore, Hong-Kong, Korea, Chinese Taipei, Finland, Liechtenstein, Switzerland, Japan, Canada, Netherlands and Macao-China (Office of the Chief Scientist, *op cit*.). Walker (2011, cited in the Office of the Chief Scientist, *op cit*.[76]) has suggested that the true ranking for Australia is 11th as ten countries had significantly higher scores. The 2009 PISA results represent a decline over time in mathematical literacy; Thomson et al. (2010) suggest that 'the average mathematical literacy performance of Australia declined significantly (by 10 score points) between PISA 2003 and PISA 2009, while there was no significant change in the OECD average over this time' (*op cit.,* p. vii).

Figure 10: Mean performance on the mathematical literacy scale: top 20 PISA participants, 2009



Source: Walker, 2011 cited in Health of Australian Science, 2012, p. 25

In terms of variations in mathematical literacy performance, there was significant disparity between the states and territories, with students in Western Australia and the

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[75] Thomson, S, De Bortoli, L, Nicholas, M, Hillman, K & Buckley, S 2010, Challenges for Australian education: results from PISA 2009 : the PISA 2009 assessment of students' reading, mathematical and scientific literacy, viewed 11 January 2013, http://research.acer.edu.au/ozpisa/9

[76] Walker, M 2011, *PISA 2009 Plus Results: performance of 15-year-olds in reading, mathematics and science for 10 additional participants*, ACER Press, Melbourne.

Australian Capital Territory achieving the highest raw mean scores, and students in Tasmania and the Northern Territory recording the lowest raw mean scores. Males on average scored significantly higher than females, and non-Indigenous students on average scored significantly higher than Indigenous students, by 76 points, or equivalent to almost two years of schooling (Thomson et al, *op cit*., p. viii). Comparing the unadjusted means for the three main schools sectors, students from independent schools achieved, on average, significantly higher than students from Catholic and government schools, and students in Catholic schools significantly outperformed those in the government schools. However, it is important to note that once differences in students' SES backgrounds are taken into account there are no statistically significant differences in the average mathematics score by sector. Students from metropolitan schools significantly outperformed students from provincial and remote schools, and students from high SES backgrounds on average significantly outperformed higher than students from low SES backgrounds. In many instances these disparities were large:

> the performance gap between students of the same age from different backgrounds can be equivalent to up to three years of schooling. This gap places an unacceptable proportion of 15-year-old students at serious risk of not achieving significant levels sufficient for them to effectively participate in the 21st century workforce and to contribute to Australia as productive citizens
> (*ibid*. p. xiv).

In reflecting on these performance gaps, the *Review of Funding for Schooling* stated that:

> The absolute decline in performance as measured by PISA in reading and mathematical literacy is evident at all levels of achievement. Australia's weak performance in reading and mathematics compared to Canada (a similar country) and Singapore (our nearest Asian neighbour participating in PISA) illustrates a serious cause for concern and suggests significant educational reform is needed to address the competitive disadvantage our children face (Gonski et al, *op cit*, p. 211).

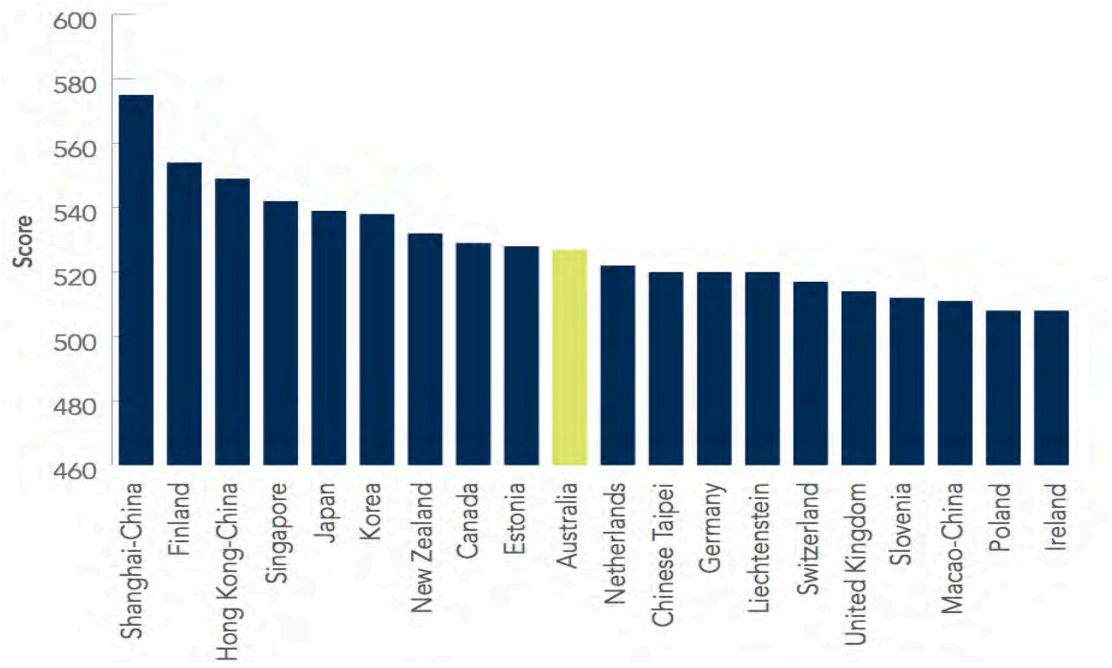
Scientific literacy, 15 year old students

The 2009 PISA results indicate that in terms of scientific literacy, Australian 15-year-olds achieved on average score (527) significantly higher than the OECD average (501). This result places Australian students at equal 7th, being significantly outperformed by Shanghai-China, Finland, Hong Kong, Singapore, Japan and Korea. Walker (2011[77]) has suggested that the true ranking is 6th as only five countries had significantly higher scores. The 2009 PISA results indicate greater disparity between the highest and lowest performing students in terms of scientific literacy than the OECD average (*ibid*.).

In terms of variations in scientific literacy performance, there was considerable disparity between the states and territories, with the students in the Australian Capital Territory and Western Australia recording the highest raw mean scores, and students in Tasmania and the Northern Territory recording the lowest raw mean scores. No significant variation according to gender was found. Non-Indigenous students on average achieved significantly higher than Indigenous students, by 81 points, or equivalent to more than 2 years of schooling (*ibid*, p. viii).

Figure 11: Mean performance on the scientific literacy scale: top 20 PISA participants, 2009

[77] Cited in the Office of the Chief Scientist, 2012, *Health of Australian Science*, Australian Government, Canberra, 2012, p. 25.



Source: Walker, 2011 cited in Office of the Chief Scientist 2012, *Health of Australian Science*, p. 25.

National Assessment Program – Literacy and Numeracy (NAPLAN), Years 7 and 9 students

The 2012 NAPLAN results with respect to Year 7 and 9 numeracy are reported in the *NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy National Report for 2012* (ACARA, 2012[78]). The results reveal persistent differences in numeracy achievement between states and territories and significant underperformance in some jurisdictions (particularly the Northern Territory). The results also reveal lower mean numeracy scale scores for female students, Indigenous students (particularly remote and very remote Indigenous students) and students based in remote and very remote locations. Slightly lower numeracy performance was reported for students with an English speaking background. Years 7 and 9 student numeracy performance was positively correlated with parental background and occupation.

TERTIARY SECTOR

Vocational education and training sector

The Australian tertiary sector includes self-accrediting providers such as the Batchelor Institute of Indigenous Tertiary Education and a large number of state and territory accredited providers including public Technical and Further Education (TAFE) colleges and private providers. In addition to vocational education and training (VET) programs, some of these non-university providers deliver undergraduate degrees, postgraduate coursework and research programs. The Tertiary Education Quality and Standards Agency (TEQSA), recently established by the Commonwealth government as the sector regulator, maintains a National Register of Tertiary Providers.

University sector

[78] Australian Curriculum, Assessment and Reporting Authority 2012, *NAPLAN Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy: National Report for 2012,* ACARA, Sydney, viewed 6 January 2013, http://www.nap.edu.au/verve/_resources/NAPLAN_2012_National_Report.pdf.

The Australian university sector comprises 40 publicly funded, self-accrediting universities including three private universities (Bond University, The University of Notre Dame Australia and MCD University), and two international universities (University College London and Carnegie Mellon University). Most Australian universities are members of at least one grouping of like institutions including the Group of Eight (GO8), Australian Technology Network, Innovative Research Universities, Regional Universities Network, Universitas 21 and Open Universities Australia.

Characteristics of the sector

In 2010, the vocational education and training (VET) sector catered for 1,799,000 students (655,800 effective full time students), enrolled in courses in dual-sector universities (8.2 per cent of the total), TAFE institutes (70.8 per cent), public universities (0.3 per cent) and other training providers (20.7 per cent). The higher education sector catered for 1,192,700 students (861,500 EFT), enrolled through dual-sector universities (10.1 per cent of the total), TAFE institutes (0.3 per cent), public universities (83.2 per cent) and other training providers (6.4 per cent).

Table 9: Tertiary education provider type profile, 2010

Provider type	VET[1]		Higher education[2]		Total	
	('000)	%	('000)	%	('000)	%
Equivalent full-time students						
Dual-sector universities[4]	53.8	8.2	87.0	10.1	140.8	9.3
TAFE institutes[4]	464.5	70.8	2.5	0.3	467.0	30.8
Public universities[4]	2.0	0.3	716.5	83.2	718.5	47.4
Other providers[4]	135.5	20.7	55.5	6.4	191.0	12.6
Total	**655.8**	**100.0**	**861.5**	**100.0**	**1 517.3**	**100.0**
Students						
Dual-sector universities[4]	104.4	5.8	118.6	9.9		
TAFE institutes[4]	1 182.9	65.8	3.5	0.3		
Public universities[4]	4.5	0.2	992.3	83.2	Not provided[3]	
Other providers[4]	491.2	27.3	78.3	6.6		
Students attending various providers[5]	16.0	0.9	-	-		
Total	**1 799.0**	**100.0**	**1 192.7**	**100.0**		

A dash (-) represents a true zero figure, with no data reported in this category. For notes on tables, see page 27.

Sources: Data on vocational education and training were derived from the National VET Provider Collection. Data on higher education were derived from the Higher Education Statistics Collection.

Source: NCVER, Tertiary education and training in Australia 2010

In 2010, the vocational education and training sector enrolled students in programs spanning Australian Qualification Framework (AQF) levels 1-8 (Certificate 1 – Graduate Certificate or Graduate Diploma) and non-AQF programs, and the higher education sector enrolled students in programs spanning AQF levels 5 – 10 (Diploma – Doctoral degree)[79]. In terms of AQF programs, the majority of VET students enrolled in Certificate Level III programs (34.3 per cent), whereas the majority of higher education students enrolled in Bachelor degree (Pass and Honours) programs (73.6 per cent).

Table 10: Equivalent full-time domestic and international students by sector of education and selected course characteristics, 2010

	VET[1]		Higher education[2]		Total	
	('000)	%	('000)	%	('000)	%
Qualification level						
AQF qualifications						
Doctoral degree	-	-	35.2	4.1	35.2	2.3
Master's degree	-	-	109.6	12.7	109.6	7.2
Graduate certificate or graduate	0.4	0.1	34.7	4.0	35.2	2.3

79 Office of the Australian Qualifications Framework Council 2012, *AQF Qualifications*, viewed 18 February 2013, http://www.aqf.edu.au/AbouttheAQF/AQFQualifications/tabid/98/Default.aspx.

diploma						
Bachelor degree (Pass and Honours)	1.2	0.2	634.2	73.6	635.4	41.9
Advanced diploma	27.0	4.1	3.7	0.4	30.7	2.0
Associate degree	0.1	0.0	6.6	0.8	6.7	0.4
Diploma	113.2	17.3	17.3	2.0	130.6	8.6
Certificate IV	114.8	17.5	-	-	114.8	7.6
Certificate III	225.2	34.3	-	-	225.2	14.8
Certificate I or II	116.1	17.7	-	-	116.1	7.6
AQF sub-total	*598.1*	*91.2*	*841.3*	*97.7*	*1 439.4*	*94.9*
Non-AQF qualifications						
Other recognised courses	42.6	6.5	10.2	1.2	52.8	3.5
Non-award courses	8.4	1.3	8.4	1.0	16.9	1.1
Subject only—no qualification	6.7	1.0	-	-	6.7	0.4
Cross-provider programs	-	-	1.5	0.2	1.5	0.1
Non-AQF sub-total	*57.7*	*8.8*	*20.2*	*2.3*	*77.9*	*5.1*
Field of education						
Natural and physical sciences	**4.6**	**0.7**	**62.4**	**7.2**	**67.0**	**4.4**
Information technology	**17.4**	**2.7**	**33.9**	**3.9**	**51.3**	**3.4**
Engineering and related technologies	**110.6**	**16.9**	**65.6**	**7.6**	**176.2**	**11.6**
Architecture and building	47.4	7.2	21.4	2.5	68.8	4.5
Agriculture, environmental and related studies	**31.2**	**4.8**	**12.5**	**1.5**	**43.8**	**2.9**
Health	**31.2**	**4.8**	**126.8**	**14.7**	**158.0**	**10.4**
Education	15.5	2.4	74.6	8.7	90.1	5.9
Management and commerce	133.9	20.4	228.6	26.5	362.5	23.9
Society and culture	103.0	15.7	160.3	18.6	263.3	17.4
Creative arts	32.6	5.0	61.9	7.2	94.5	6.2
Food, hospitality and personal services	49.5	7.5	0.8	0.1	50.2	3.3
Mixed field programs	72.4	11.0	4.1	0.5	76.5	5.0
Not applicable[6]	6.7	1.0	8.4	1.0	15.1	1.0
Total	**655.8**	**100.0**	**861.5**	**100.0**	**1 517.3**	**100.0**

A dash (-) represents a true zero figure, with no data reported in this category. For notes on tables, see page 27.

Sources: Data on vocational education and training were derived from the National VET Provider Collection. Data on higher education were derived from the Higher Education Statistics Collection.

Source: NCVER, Tertiary education and training in Australia 2010

In terms of the field of education, 195,000 effective full time VET students were enrolled in STEM disciplines (Natural and Physical Sciences, Information Technology, Engineering and Related Technologies, Agriculture Environmental and Related Studies), representing 29.9 per cent of all VET EFT enrolments. Over half of these enrolments were in the Engineering and related technologies field of education. 349,000 EFT higher education students were enrolled in STEM disciplines, representing 32.7 per cent of all higher education enrolments. Over a third of these enrolments were in the Health field of education. In total, 496,300 EFT VET and higher education students were enrolled in STEM disciplines in 2010, representing a total of 32.7 per cent of all enrolments.

Table 11: Equivalent full-time domestic and international students by sector of education and selected course characteristics for all students, males, females, aged 24 years and under, 2010

	All students		**Males**		**Females**		**Aged 24 years and under**	
	VET[1]	Higher education[2]	VET[1]	Higher education[2]	VET[1]	Higher education[2]	VET[1]	Higher education[2]
Qualification level								
AQF qualifications								
Doctoral degree	**-**	**4.1**	**-**	**4.6**	**-**	**3.7**	**-**	**0.8**
Master's degree	**-**	**12.7**	**-**	**13.7**	**-**	**12.0**	**-**	**7.0**
Graduate certificate or graduate diploma	**0.1**	**4.0**	**0.1**	**3.6**	**0.1**	**4.4**	**0.0**	**1.6**
Bachelor degree (Pass and Honours)	**0.2**	**73.6**	**0.1**	**71.9**	**0.2**	**75.0**	**0.2**	**84.6**
Advanced diploma	4.1	0.4	4.5	0.5	3.8	0.4	4.5	0.5
Associate degree	0.0	0.8	0.0	1.1	0.0	0.5	0.0	0.7
Diploma	17.3	2.0	13.1	2.4	21.6	1.7	14.8	2.5
Certificate IV	17.5	-	15.8	-	19.2	-	12.9	-
Certificate III	34.3	-	38.6	-	30.0	-	38.9	-
Certificate I or II	17.7	-	18.7	-	16.7	-	21.0	-
AQF sub-total	*91.2*	*97.7*	*90.9*	*97.7*	*91.5*	*97.6*	*92.4*	*97.6*
Non-AQF qualifications								
Other recognised courses	6.5	1.2	6.8	1.1	6.2	1.3	5.7	1.1
Non-award courses	1.3	1.0	1.4	1.0	1.1	1.0	1.6	1.1
Subject only—no qualification	1.0	-	0.8	-	1.2	-	0.3	-
Cross-provider programs	-	0.2	-	0.2	-	0.2	-	0.2
Non-AQF sub-total	*8.8*	*2.3*	*9.1*	*2.3*	*8.5*	*2.4*	*7.6*	*2.4*
Field of education								
Natural and physical sciences	**0.7**	**7.2**	**0.5**	**7.7**	**0.9**	**6.9**	**0.7**	**7.8**
Information technology	**2.7**	**3.9**	**4.3**	**7.2**	**1.0**	**1.3**	**3.3**	**3.9**
Engineering and related technologies	**16.9**	**7.6**	**30.5**	**14.3**	**2.8**	**2.3**	**19.0**	**8.4**
Architecture and building	7.2	2.5	13.1	3.3	1.2	1.8	10.1	2.7
Agriculture, environmental and related studies	**4.8**	**1.5**	**6.8**	**1.6**	**2.6**	**1.4**	**4.0**	**1.3**
Health	**4.8**	**14.7**	**2.2**	**9.3**	**7.4**	**19.1**	**3.6**	**13.5**
Education	2.4	8.7	1.8	4.8	2.9	11.8	0.6	7.3
Management and commerce	20.4	26.5	13.8	29.3	27.2	24.3	19.9	28.3
Society and culture	15.7	18.6	7.8	15.0	23.8	21.5	12.0	17.2
Creative arts	5.0	7.2	4.0	6.2	6.0	8.0	6.5	8.1
Food, hospitality and personal services	7.5	0.1	5.0	0.1	10.1	0.1	10.1	0.1
Mixed field programs	11.0	0.5	9.2	0.4	13.0	0.5	9.9	0.4
Not applicable[6]	1.0	1.0	0.8	1.0	1.2	1.0	0.3	1.1
Total (%)	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Total ('000)	**655.8**	**861.5**	**331.8**	**383.9**	**322.7**	**477.6**	**321.8**	**623.8**

A dash (-) represents a true zero figure, with no data reported in this category. For notes on tables, see page 27.

Sources: Data on vocational education and training were derived from the National VET Provider Collection. Data on higher education were derived from the Higher Education Statistics Collection.

Source: NCVER, Tertiary education and training in Australia 2010

In terms of gender representation, while more females enrolled in VET (322,700) than males (331,800) in 2010, far more males than females enrolled in STEM disciplines (44,300 males versus 14,700 females). Similarly in the higher education sector, more females were enrolled overall than males (477,600 versus 383,900), however females were under-represented in STEM disciplines overall in the higher education sector (40,100 males versus 31,000 females). The inclusion of the Health field of education, which enrols 19,100 females, decreases the gender disparity in STEM disciplines considerably. The greatest disparity in higher education STEM discipline enrolments is in

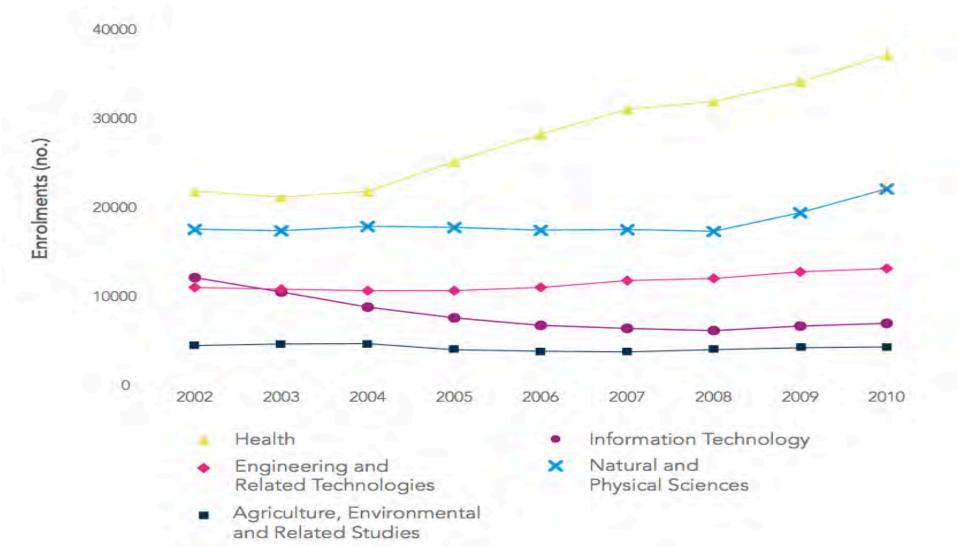
Information Technology (7,200 males versus 1,300 females) and Engineering (14,300 versus 2,300).

UNIVERSITY

PARTICIPATION IN STEM

Commencing enrolments – bachelor degrees

Figure 12: Commencing domestic bachelor's (pass and grad.entry) enrolments: science-related Fields of Education



Source: Office of the Chief Scientist 2012, *Health of Australian Science*, p. 70.

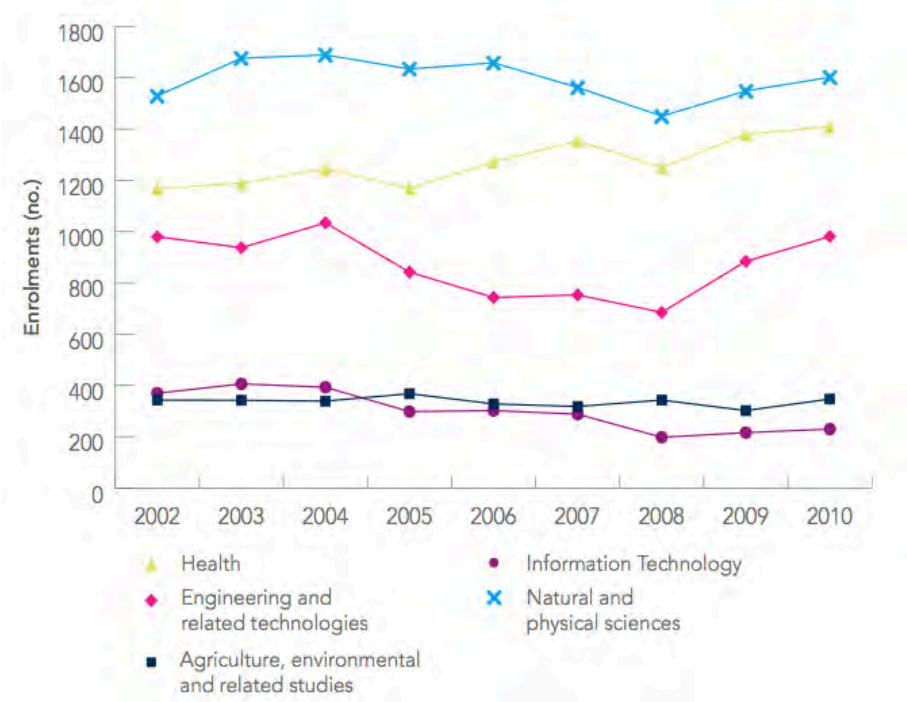
For the period 2002-2010, commencing domestic undergraduate enrolments increased overall by 23.6 per cent, however there was variation at the field of education level. In terms of participation in STEM undergraduate awards, enrolments in Health increased significantly (by 73.0 per cent) to represent 17.9 per cent of all commencing undergraduate enrolments[80]. Enrolments in Natural and Physical Sciences remained flat for the period 2002-2007 then grew by 29 per cent (2008-2010), to represent 10.5 per cent of all commencing undergraduate enrolments. Enrolments in Engineering increased by 21 per cent from a low base (representing growth in student numbers from approximately 10,000 to 12,400), such that Engineering represented 6.1 per cent of all commencing undergraduate enrolments. Enrolments in Information Technology decreased by approximately 50 per cent, to represent 3 per cent of all commencing domestic undergraduate enrolments in 2010. Enrolments in Agriculture and Environment remained relatively static (recording a decrease from a low base of 4 per cent, which included a decline by 31 per cent in the discipline of Agriculture), to represent 1.7 per cent of all commencing domestic undergraduate enrolments (Office of the Chief Scientist, *op cit*.). Commencing international undergraduate enrolments increased more than domestic enrolments. These low levels of participation in STEM undergraduate awards have remained persistent following declines recorded earlier in the late 1990s.

For the period 2002-2010, commencing domestic higher degree by research enrolments remained relatively static, with some variation noted at the field of education level. In terms of participation in STEM higher degrees by research, enrolments in Natural and

80 The overall decline in STEM-discipline enrolments would appear if Nursing had not been made a university degree level program.

Physical Sciences fluctuated and approximately 1,600 students commenced in 2010. Enrolments in Health grew by 21 per cent over this period (from 1168 to 1410); enrolments in Engineering and Related Technologies declined for several years then returned to 2002 levels (to approximately 1000); enrolments in Agriculture, Environmental and Related Studies remained steady at approximately 350; and enrolments in Information Technology declined from 370 to 230 (Dobson, 2012[81]).

Figure 13: Domestic commencing HDR enrolments: science-related FoEs

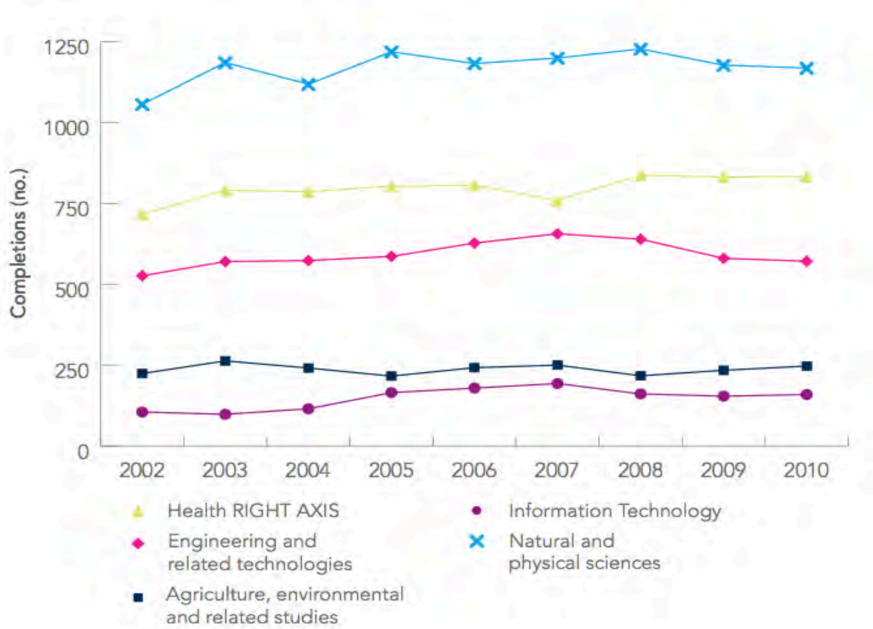


Source: Office of the Chief Scientist 2012, *Health of Australian Science*, p. 75.

Domestic higher degree by research completions increased for the period 2002-2010. However the *Health of Australian Science* report suggests some caution is taken in interpreting this data.

[81] Dobson, I 2012, *Unhealthy Science? University Natural and Physical Sciences 2002 to 2009/10*, report commissioned for the Office of the Chief Scientist, viewed 11 January 2013, http://www.chiefscientist.gov.au/wp-content/uploads/Unhealthy-Science-Report-Ian-R-Dobson.pdf.

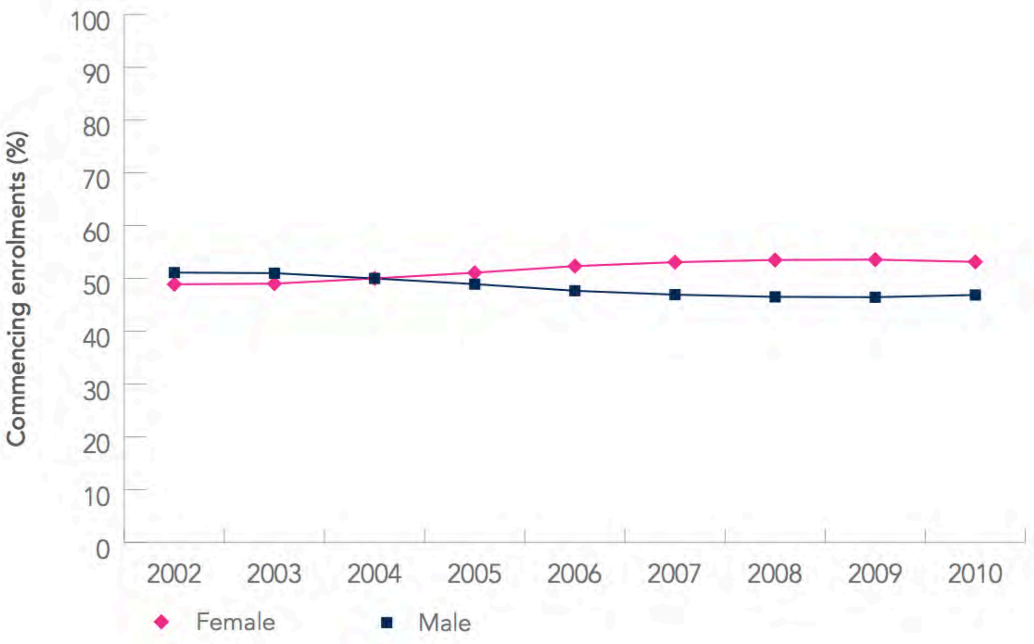
Figure 14: Domestic HDR completions: science-related FoEs



Source: Office of the Chief Scientist 2012, *Health of Australian Science*, p. 75.

Gender balance, university enrolments

Figure 15: Proportion of domestic commencing undergraduate enrolments, by gender: science-related Fields of Education

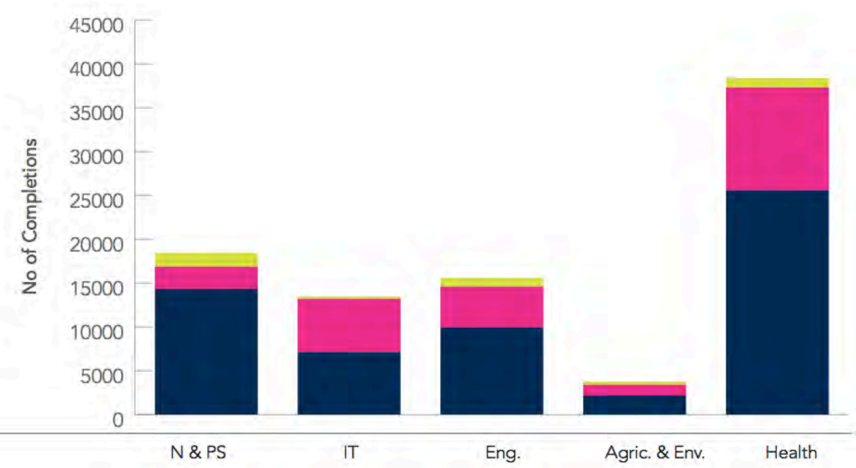


Source: Office of the Chief Scientist 2012, *Health of Australian Science*, p 72.

In 2010, women's participation in science-related disciplines was almost equivalent to all enrolments (54 per cent of all science-related domestic commencing undergraduate enrolments in Agriculture and Environment, Engineering, Health, Information Technology and Natural and Physical Sciences), compared to 55.6 per cent of all enrolments. However, significant gender-based variations exist at the field of education level for science-related students. Domestic women students' representation in undergraduate commencing enrolments includes Health (almost 80 percent), Agriculture and Environment (evenly represented, slightly higher women), Natural and Physical Sciences (52 per cent), Engineering and Related Technologies (20 per cent) and Information Technology (14.1 per cent) (*ibid*.). Women's under-representation in Engineering and related technologies, and Information Technology fields of education are longstanding.

University student completions

Figure 16: Number of student completions (domestic and international): science-related fields of education, by course level, 2010



	N & PS	IT	Eng.	Agric. & Env.	Health
Postgraduate research	1589	262	986	370	1053
Postgraduate coursework	2535	6059	4637	1215	11726
Undergraduate	14344	7147	9967	2188	25597

Source: Department of Education, Employment and Workplace Relations.

Source: Office of the Chief Scientist 2012, *Health of Australian Science*, p. 26.

In 2010, approximately 285,000 course completions were recorded across all fields of education and levels (undergraduate, postgraduate), for both domestic and international students[82]. Of this, approximately 90,000 course completions were in science-related fields of education, which were generally consistent with enrolments. The largest numbers completing were in Health (approximately 38,000), and the lowest in Agriculture and Environmental Sciences (approximately 3,800). The largest number of higher degree by research student completions were in the Natural and Physical Sciences (1,589). Indicative completion rates for undergraduate students varied, with the highest recorded in Health (73 per cent) and Natural and Physical Sciences (69 per cent), and lower indicative completion rates recorded in Engineering (58 per cent), Agriculture and Environment (56 per cent) and Information Technology (50 per cent). Completion rates for higher degree by research students in science-related fields of education were generally higher than the average, with the exception of Information Technology (*ibid*.).

VET engineering programs

In terms of vocational education and training engineering programs, 3,380 VET engineering award completions were recorded in 2009, including Associate Diploma completions (43), Advanced Diploma completions (1,110) and Diploma completions

82 Domestic students comprised 69 percent of all completions in science-related Fields of Education in 2010 (OCS, *op cit*.).

(2,236) (Watson and McIntyre, 2011[83]). VET completions represented approximately one quarter of all undergraduate engineering qualification completions in 2009 (12,724), however they were exclusively delivered at the para-professional level (Australian Qualification Framework Level V and VI). Delivery at this level represented a very small proportion of the total number of VET engineering award completions (1.19 per cent), with the vast majority of engineering awards delivered at AQF Levels I-IV (*ibid*). Whilst undergraduate VET engineering awards primarily support employment outcomes at the para-professional level (for example, Engineering Associate – technician), VET qualifications provide an articulation pathway to higher education engineering qualifications, particularly in dual sector higher education institutions (King, 2011)[84]. Despite this, enrolments in engineering VET qualifications at Diploma and higher levels decreased over the period 2005-2010 (AWPA, 2012 based on NCVER unpublished data).

Adult educational achievement

The upper secondary graduation rate for Australians under the age of 25 is higher in general programs (70 per cent versus 49 per cent) and lower in pre-vocational and vocational programs (23 per cent versus 35 per cent) compared to the OECD norms (OECD, 2012[85]. These rates should be interpreted carefully as they represent the estimated percentage of people from a certain age cohort that is expected to graduate at some point during their lifetime and is sensitive to changes in the duration of the programs.

The educational attainment of 25-64 year old Australians in 2010 is presented below. Up to 73 per cent of the Australian population aged 25-64 years had completed at least upper secondary level education or more. This figure is up to 85% among those aged 25-34 years, above the OECD average of 82 per cent for this group. As many as 27 per cent of Australians aged 25-64 years have attained tertiary type A (bachelor or other undergraduate level program) and advanced research programs, above the OECD average of 22 per cent. Among Australians aged 25-34 years, 34 per cent had attained up to bachelor or advanced research programs in 2010.

Table 12: Educational attainment of Australians aged 25-64 years in 2010

	At least upper secondary (%)	Tertiary type A and advanced research programmes (%)
Australia	73	27
OECD Average	74	22

Source: OECD, 2012

PARTICIPATION AND PERFORMANCE IN STEM – DISADVANTAGED COHORTS

The *Review of Funding for Schooling* (Gonski review) found that:

> … on average, students from low socioeconomic backgrounds, Indigenous students, students with disability, students from remote and very remote areas, and to variable degrees LBOTE students: are more likely to be considered developmentally vulnerable at school entry, have lower performance on assessments throughout schooling, with the gap getting larger in the later years of schooling, have lower Year 12 and equivalent attainment rates (Gonski et. al, op cit., p. 28).

83 Watson, L & McIntyre, J 2011, *Building engineering workforce capacity through education and training*, Skills Australia Seminar, 1 December 2011.

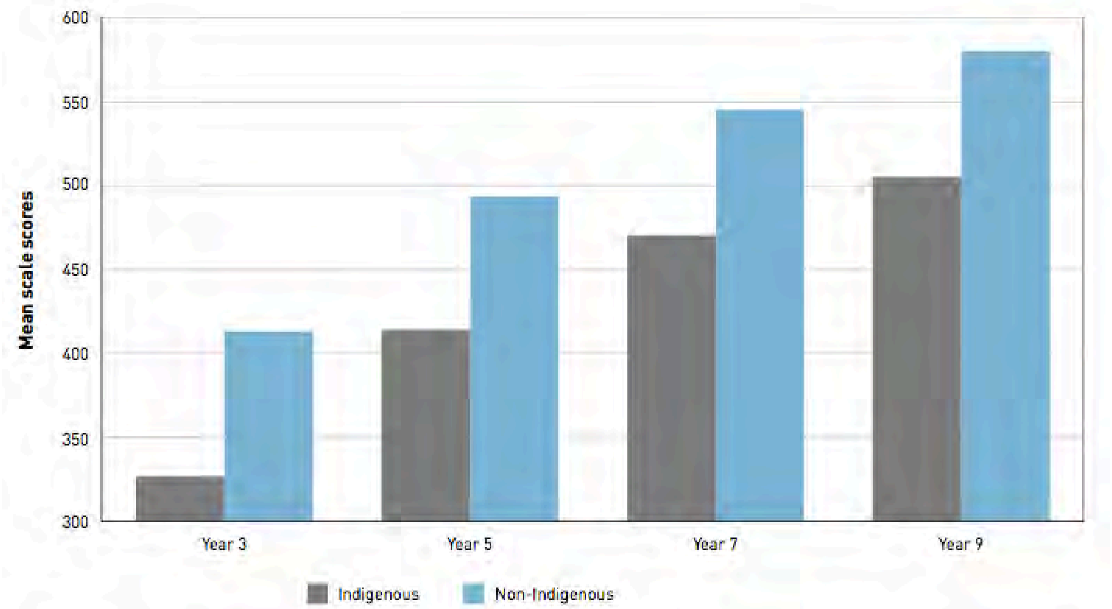
84 King, RW 2011, *Pathways between VET qualifications and Engineering Degrees*, Skills Australia Seminar, 1 December 2011.

85 OECD 2012, *Education at a Glance 2012; OECD Indicators*, OECD Publishing, Paris.

Disparities with respect to school education participation and performance influence access to and participation in school science, mathematics and technology, and university STEM education and research. The NAPLAN, NAP-SL, PISA and TIMSS assessments all attest to these disparities.

The NAPLAN 2010 results reveal significant disparity between Indigenous and non-Indigenous Years 3, 5, 7 and 9 students with respect to reading, writing, spelling, grammar and punctuation, and numeracy.

Figure 17: Indigenous and non-Indigenous NAPLAN performance, Years 3, 5, 7 and 9, 2010



Note: Mean scale score refers to achievement across the five NAPLAN domains of reading, writing, spelling, grammar and punctuation, and numeracy.

Source: Gonski et al, 2012, op cit., p. 116 (adapted from MCEECDYA 2011, using data from ACARA 2010).

As noted earlier, in terms of NAPLAN numeracy results specifically, a large percentage of Indigenous students in remote and very remote locations did not meet the minimum national standards for numeracy (45 per cent remote; 71 per cent very remote). The 2009 PISA results confirm this disparity.

In terms of participation in university, Indigenous students comprised 1.4 per cent of all enrolments in 2010 (DIISRTE, 2012 cited in Behrendt et al, 2012[86]). They were less likely than non-Indigenous people to participate: 2.8 per cent of the Indigenous working-age population participated in university in 2006 compared to 5 per cent of the non-Indigenous working-age population (ABS 2012 and DIISRTE 2012 cited in Behrendt et al, 2012). In terms of STEM, participation in science and engineering degrees is much lower for Indigenous people than non-Indigenous people (e.g. Science: 7.3 per cent non-Indigenous student enrolments compared with 3.4 per cent Indigenous; Engineering: 6.5 per cent non-Indigenous student enrolments compared with 2.3 per cent Indigenous).

[86] Behrendt, L, Larkin, S, Griew, R & Kelly, P 2012, *Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People: Final Report*, viewed 15 March 2013, http://www.innovation.gov.au/HigherEducation/IndigenousHigherEducation/ReviewOfIndigenousHigherEducation/FinalReport/IHERFinalReport.pdf.

Data for commencements by field of education, and completions showed similar disparities (Behrendt, 2011[87]).

There have been persistent disparities with respect to the participation of people in rural and remote locations, particularly Indigenous peoples living in such locations. The Australian Human Rights and Equal Opportunity Commission (HREOC) conducted a national inquiry into rural and remote education in 1999, including consideration of the availability and accessibility of primary and secondary education. The inquiry considered the particular challenges faced by young people in remote locations, including those: with disabilities, with limited access to public transport, undertaking distance education with limited information technology communication infrastructure, and forced to relocate and board to undertake schooling. The inquiry also considered issues facing Indigenous young people, including those located in communities without access to schools, teachers, support for distance education or curriculum, and those Indigenous young people from non-English speaking backgrounds.

"Education Access": National Inquiry into Rural and Remote Education reports that:

> The inquiry was disturbed to find extensive de facto racial segregation in which one of the local schools (typically the Catholic primary school in the Kimberley region of WA but the government primary school in north-west NSW) enrols predominantly Indigenous students while the other is the school of choice for local white families. For rural families education 'choice' at the secondary level has traditionally been secured by the option of capital city boarding schools. The expense of this option has always excluded many. (HREOC, 2000a)

The HREOC *"Recommendations": National Inquiry into Rural and Remote Education* (HREOC, 2000b[88]) reported that young people in rural and remote locations were less likely to complete schooling, and more at risk in terms of their transition to employment, or further education and training. Whilst the inquiry did not specifically focus on science, technology, engineering and mathematics, the inquiry's overall findings suggest that the pool of young people available to transition to STEM-related higher education and employment is constricted due to diminished access to schooling education. Outcomes were exacerbated for Indigenous young people, and young people with disabilities living in rural and remote locations.

Participation of people from rural and remote regions in higher education is lower than those from metropolitan areas: 'for every ten people from urban locations who go to university, only six people from rural or isolated Australia do so' (James, 2002, p. 1)[89]. This finding is consistent with various government reports and research publications (Allway et al, 2004; Hillman and Rothman, 2007)[90]. Participation stalls at entry to university, with Victorian-specific higher education participation research revealing

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87 Behrendt, L 2011, *Review of higher education access and outcomes for Aboriginal and Torres Strait Islander People Context paper and call for submissions*, viewed 15 March 2013, http://www.innovation.gov.au/HIGHEREDUCATION/INDIGENOUSHIGHEREDUCATION/REVIEWOFINDIGENOUSHIGHEREDUCATION/Pages/default.aspx.

88 Human Rights and Equal Opportunity Commission 2000, *"Recommendations": National Inquiry into Rural and Remote Education*. Australian Government, Canberra, viewed 8 January 2012, http://humanrights.gov.au/pdf/human_rights/rural_remote/Rec_book.pdf.

89 James, R 2002, *Socioeconomic Background and Higher Education Participation: An analysis of school students' aspirations and expectations*, The University of Melbourne: Centre for the Study of Higher Education, Melbourne.

90 Alloway, N, Gilbert, P, Gilbert, R & Muspratt, S 2004, *Factors impacting on student aspirations and expectations in regional Australia*, Townsville, James Cook University; Hillman, K & Rothman, S 2007, *Movement of Non-metropolitan Youth towards the Cities*, Longitudinal Surveys of Australian Youth Research Report 50.

differences in application, rejection and deferral rates (Parliament of Victoria, 2009)[91]. These disparities may be attributed to issues of geographical proximity to education institutions and related financial considerations, and be exacerbated by socio-economic disadvantage. In addition, participation rates for rural and remote people in higher education may result from differences in terms of aspiration to higher education, and school completion and achievement (Parliament of Victoria, *op cit*.).

The gap between metropolitan and rural and regional students in terms of participation and performance appears to be growing (Senate Rural and Regional Affairs and Transport References Committee, 2009[92]). The Senate inquiry into *Rural and Regional Access to Secondary and Tertiary Education Opportunities* received evidence regarding inequities arising from financial barriers involved in participation in higher education (for example, moving from a rural or remote location to study), and issues associated with inadequate income support. The inquiry also heard evidence regarding social and community costs associated with young people's relocation away from home to pursue higher education opportunities (Senate Rural and Regional Affairs and Transport References Committee, 2009). These findings were confirmed in the *Review of Australian Higher Education Final Report* (the Bradley Review), which found that 'people from regional and remote parts of Australia remain seriously under-represented in higher education and the participation rates for both have worsened in the last five years' (2008, p. 31)[93]. The final report recommended innovative initiatives be introduced to support participation of people from regional and remote backgrounds in higher education.

In terms of performance, the NAPLAN 2010 results identified significant differences in Year 7 and Year 9 numeracy between students in metropolitan and remote and very remote locations (ACARA, *op cit.).* Similar findings were reported in the 2009 PISA results regarding mathematical and scientific literacy for 15 year olds (Thomson et al, *op cit.*). In addition to disparities in performance in the enabling sciences and mathematics, fewer students from remote and very remote locations completed Year 12 (67 per cent of 20-24 year olds had attained Year 12, compared to 81 per cent of metropolitan 20-24 year olds) (ABS, 2011 cited in Gonski et al, *op cit*.), and subsequently, fewer transitioned to university. The *SiMERR National Survey, 2006* revealed that the differences based on geographical location regarding science and mathematics achievement are longstanding (Lyons et al., 2006[94]).

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91 Parliament of Victoria 2009, *Final Report: Inquiry into Geographical Differences in the Rate in which Victorian Students Participate in Higher Education*, Victorian Government, Melbourne, viewed 3 January 2013, http://www.parliament.vic.gov.au/images/stories/committees/etc/HE_Report/hepreliminaries.pdf.

92 Senate Standing Committee on Rural & Regional Affairs & Transport 2009, *Rural and Regional access to Secondary and Tertiary Education Opportunities*, Australian Government, Canberra.

93 Bradley D. et al., 2008, *Review of Australian Higher Education: Final Report*, Australian Government, Canberra, viewed 28 December 2012, http://www.innovation.gov.au/HigherEducation/Documents/Review/PDF/Higher%20Education%20Review_one%20document_02.pdf.

94 Lyons, T, Cooksey, R, Panizzon, D, Parnell, A & Pegg, J 2006, *The SiMERR National Survey*, prepared for the Department of Education, Science and Training, viewed 11 January 2013, http://www.une.edu.au/simerr/pages/projects/1nationalsurvey/index.html.

ROLE OF SCIENCE AND MATHS AS UNIVERSITY SELECTORS

The *Health of Australian Science* reports that senior secondary school science is primarily concerned with preparation for university science, rather than development of scientific literacy for the broader cohort (ETC 2006 cited in Office of the Chief Scientist, *op cit.*). This focus on science as a university selector exacerbates the senior secondary science curriculum content demands, creating 'an overcrowded and content-laden curriculum … (which) re-inforces both the traditional transmission model of teaching science in Years 11 and 12 and a narrow and rigid assessment regime' (Goodrum et al, 2012 cited in Office of the Chief Scientist, *op cit*., p. 54).

TEACHERS

Teaching quality is considered to be the most important in-school factor for student performance (OECD, 2005[95]; Hattie, 2008[96]). The Department of Education, Employment and Workplace Relations has collected data relating to teaching quality including entry-level qualifications, methodology training, professional development and supply in the *Staff in Australia's Schools* (SiAS) surveys of teachers and school leaders conducted by the Australian Centre for Educational Research (ACER). The most recent survey results are available in *Staff in Australia's Schools 2010: Main Report of the Survey* (McKenzie et al, 2011[97]).

Teacher's qualifications

Eligibility requirements for teaching qualifications are low, and at least in some jurisdictions decreasing. For example, the latest round of Victorian university teaching program offerings reveals that ATAR[98] scores have decreased in several universities between 2012 and 2013 (Ballarat - Education, decreased from ATAR of 46.55 in 2012 to 43.35 in 2013; Deakin - Teaching – Secondary/Arts decreased from 70.95 in 2012 to 51.55 in 2013; Latrobe Education [P-10] decreased from 71.4 in 2012 to 70.8 in 2013) (The Age, 20 January 2013[99]). In 2012, 2.8 per cent of total offers (19,010) for entry to education courses were made to applicants based on an ATAR of 50 or less. Most people (56.5 per cent) who gained entry to teacher education courses did so by meeting entry requirements other than the ATAR – many are mature age and have already completed a VET or higher education qualification (DIISRTE, 2012[100]).

The majority of primary school teachers hold, as their highest qualification, a Bachelor-level degree in Education (54.4 per cent), Bachelor (Honours) degree in Education (6.8 per cent), or Graduate Diploma of Education (15.9 per cent) completed following a first degree in a discipline other than Education. Few primary school teachers hold a Masters degree (7.1 per cent) or Doctoral degree (0.3 per cent). Reflecting primary school staffing structures and curriculum requirements, the majority of primary school teachers hold qualifications in the discipline of education, rather than a specialised subject area (such as science, mathematics or technology) with only 39 per cent of primary school teachers

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95 Organisation for Economic Co-operation and Development 2005, *Teachers Matter: Attracting, developing and retaining effective teachers*, OECD, Paris, viewed 7 January 2013, http://www.oecd.org/education/preschoolandschool/34990905.pdf.

96 Hattie, J 2008, *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*, Routledge, London.

97 McKenzie, P, Rowley, G, Weldon, P & Murphy, M 2011, *Staff in Australia's Schools 2010: Main Report of the Survey*, Australian Council for Educational Research, Melbourne.

98 The ATAR is a mechanism for allocating the number of places supplied in a course to match the demand. Growth in the number of places will impact the ATAR for that course.

99 The Age, *Teacher entry rankings tumbles*, 18 January 2013, viewed 20 January 2013, http://www.theage.com.au/data-point/teacher-entry-ranking-tumbles-20130117-2cwb5.html.

100 Department of Industry, Innovation, Science, Research and Tertiary Education 2012, *Undergraduate Applications Offers and Acceptances Reports*, viewed 12 March 2013, http://www.innovation.gov.au/HigherEducation/ResourcesAndPublications/HigherEducationPublications/HigherEducationReports/Pages/UndergraduateApplicationsOffersAndAcceptancesReports.aspx.

reporting a highest qualification in fields other than Education. In addition to entry-level qualifications, primary school teaching quality is therefore concerned with teacher's confidence and capacity with respect to teaching specialist content knowledge, such as science (Goodrum et al, 2001).

Table 13: Highest qualification in Education held by teachers

	PRIMARY %	SECONDARY %
Doctoral degree	0.3	0.3
Masters degree	7.1	**11.1**
Graduate Diploma	15.9	**32.2**
Graduate Certificate	2.3	2.8
Bachelor (Honours) degree	6.8	5.1
Bachelor degree	54.4	**39.5**
Diploma or Advanced Diploma	11.6	**6.8**
Other	1.6	2.3
	100.0	100.0

Source: Reproduced from McKenzie, P, Rowley, G, Weldon, P & Murphy, M 2011, *Staff in Australia's Schools 2010: Main Report of the Survey*, p. 33.

The qualifications held by secondary school teachers differ somewhat to those held by primary school teachers, with fewer secondary school teachers holding a Diploma or Advanced Diploma (6.8 per cent) or Bachelor degree in Education (39.5 per cent). More secondary school teachers hold a Graduate Diploma in Education (32.2 per cent), in addition to a first degree in another discipline, indicating that more secondary school teachers hold qualifications in a specialist discipline in addition to their Education qualification with 57.2 per cent of secondary school teachers reporting a highest qualification in fields other than Education. Marginally more secondary school teachers than primary school teachers hold a Masters degree (11.1 per cent), while the level of Doctoral degree holders was equivalent (0.3 per cent) (McKenzie et al, op cit., p. xiv).

Science, mathematics and technology specific qualifications and professional development

Table 14: Primary teachers: proportions by tertiary study by highest year level in which at least one semester has been completed, and studies in teaching methods, by area of schooling

	HIGHEST YEAR LEVEL OF TERTIARY STUDY COMPLETED			Total with some tertiary study (%)	Training in teaching methods (%)
	1 YEAR (%)	2 YEARS (%)	3+ YEARS (%)		
MATHEMATICS					
Mathematics	9.3	11.9	45.0	*66.2*	57.1
Numeracy	5.1	10.4	37.8	*53.4*	49.9
Statistics	8.6	5.7	9.3	*23.6*	7.6
SCIENCES					
Biology	6.8	3.7	5.4	*15.9*	4.4
Chemistry	4.8	2.4	2.4	*9.6*	2.3
Earth sciences	4.8	3.2	4.2	*12.3*	3.9
Environmental sciences	4.3	3.5	6.1	*13.9*	6.6
Physics	4.1	1.7	1.7	*7.4*	1.4
Psychology/Behavioural studies	5.7	5.3	11.3	*22.3*	8.9
Science - General	11.0	11.4	24.7	*47.2*	40.5
TECHNOLOGY					
Computing	12.0	7.6	14.1	*33.6*	22.2
Food technology	1.6	0.9	1.1	*3.6*	1.3
Graphic communication	1.2	0.6	0.7	*2.6*	1.0
Information technology	6.4	4.6	7.5	*18.5*	13.1
Textiles	2.0	0.9	1.5	*4.4*	1.7
Wood or metal technology	1.8	0.5	0.5	*2.8*	1.1

Source: Reproduced from McKenzie, P, Rowley, G, Weldon, P & Murphy, M 2011, *Staff in Australia's Schools 2010: Main Report of the Survey*, p. 53.

Primary school teachers were more likely to have completed tertiary study in mathematics (mathematics – 66.2 per cent; numeracy – 53.4 per cent) than in separate science subjects (between 7.4 – 22.3 per cent, with the exception of sciences: general – 47.2%) or separate technology subjects. The proportion of primary school teachers with three years mathematics education is below international averages (AMSI, 2012). Overall, while almost half of primary school teachers had completed tertiary study in general science far fewer primary school teachers had completed tertiary studies in any of the separate science subjects, with particularly low proportions having completed tertiary study in physics (7.4 per cent) or chemistry (9.6 per cent). Similarly, in terms of technology, very few primary school teachers had completed tertiary studies in any of the technology subjects with the exception of computing (33.6 per cent), and a significant proportion appear to have not completed tertiary study in any technology subject. With respect to training in teaching methods, more primary school teachers had received training in teaching methods relating to mathematics (mathematics – 57.1 per cent; numeracy – 49.9 per cent) than in separate science or technology subjects.

Table 15: Secondary teachers training in selected areas: qualifications, experience and professional learning activities

	HIGHEST YEAR LEVEL OF TERTIARY STUDY COMPLETED			**Total with some tertiary study**	**Methodology training in the area Yes (%)**	**Professional learning in past 12 months in the area Yes (%)**
	1 YEAR (%)	**2 YEARS (%)**	**3+ YEARS (%)**			
Chemistry 11-12	6.8	14.8	74.9	***96.5***	67.5	44.2
Physics 11-12	19.9	16.8	54.1	***90.9***	56.9	43.5
Mathematics 11-12	9.1	16.6	64.1	***89.7***	76.3	59.7
Mathematics 7/8-10	15.2	15.7	45.8	***76.7***	60.4	49.4
IT 11-12	11.3	8.5	46.9	***66.8***	52.0	62.6
IT 7/8-10	10.5	8.5	33.8	***52.8***	42.5	47.3

Source: Reproduced from McKenzie, P, Rowley, G, Weldon, P & Murphy, M 2011, *Staff in Australia's Schools 2010: Main Report of the Survey*, p. 53.

The proportion of secondary school teachers holding qualifications relevant to their area of teaching specialisation is a key teaching quality indicator (International Association for the Evaluation of Educational Achievement, 2012)[101]. Almost all chemistry Year 11-12 school teachers had completed some tertiary study (96.5 per cent), as had physics Year 11-12 teachers (90.9 per cent) and mathematics Year 11-12 teachers (89.7 per cent). With respect to science teachers, this finding correlates with Harris et al. (2005[102]) in terms of preference for teachers of science having a university degree in science rather than in teaching with some additional discipline training.

However, only 61.5 per cent of mathematics Year 7/8-10 teachers had two or more years' tertiary training in mathematics (the minimum required to teach mathematics subjects in most countries). This indicates that a large proportion of junior secondary mathematics teachers (38.5 per cent) teach out of field (that is, they have less than two years tertiary training in mathematics). This is a serious concern. Fewer information technology teachers had completed related tertiary study.

Teacher shortages

Australia's schools are staffed by over 300,000 school teachers (DEEWR, 2012f). Primary school principals surveyed for the *Staff in Australia's Schools* (SiAS) survey identified a small number of unfilled specialist area teaching positions at the time of the survey including science (10 positions overall), computing (110) and technology (70), in almost all cases at a rate of one position unfilled per school, where a vacancy was identified. There were no reported unfilled numeracy positions (McKenzie et al, *op cit*.), however there was a sizable number of unfilled Generalist Primary teacher positions (610) at the time of the survey (Staff in Australia's Schools [SiAS] survey, p. 108)[103].

This is confirmed in *Skills Shortages Australia*:

> There are more than adequate supplies of primary school teachers. This is evidenced by the substantial number of primary school teachers who are on standby for positions in metropolitan areas and the relatively large number of suitable applicants per vacancy, and is confirmed in commentary from some state education authorities.

101 International Association for the Evaluation of Educational Achievement 2012, *Policy, Practice, and Readiness to Teach Primary and Secondary Mathematics in 17 Countries: Findings from the IEA Teacher Education and Development Study in Mathematics (TEDS-M)*, IEA, The Netherlands.

102 Harris, KL, Jensz, F & Baldwin, G 2005, *Who's Teaching Science: Meeting the demand for qualified science teachers in Australian secondary schools*, Report prepared for Australian Council of Deans of Science, Centre for the Study of Higher Education, viewed 13 March 2013, http://www.cshe.unimelb.edu.au/people/harris_docs/Who'sTeachingScience.pdf.

103 Staff in Australia's School (SiAS) Survey, viewed http://foi.deewr.gov.au/node/25764.

> (DEEWR, 2012, p. 23)

When shortages do occur, primary school principals surveyed reported implementing a range of strategies including ‘requiring teachers to teach outside their field of expertise’ (13.6 per cent), ‘combining classes across year levels’ (10.2 per cent) and ‘reducing the curriculum offered’ (9.3 per cent). Variations were reported by school system (government, independent, Catholic) with more primary school principals from independent schools (56.4 per cent) than government schools (50.8 per cent) or Catholic schools (45.9 per cent) resorting to strategies to address staffing shortages (McKenzie et al, *op cit*.). Overall, the number of unfilled positions for primary school teachers in science, computing and technology was low, and did not represent a national skills shortage. Having said that, concerns have been raised regarding the capacity of teachers, with the Australian Mathematical Sciences Institute calling on the government to ensure teachers are ‘mathematically prepared’.

Secondary school principals identified larger numbers of unfilled teaching positions at the time of the survey including 400 in mathematics (390 positions in mathematics; 10 in statistics), 190 in science (chemistry – 80; physics – 50; science: general – 50 and biology – 10) and 310 in technology (computing – 30; information technology – 130; and wood or metal technology – 120). In many instances individual schools reported vacancies of more than one unfilled teacher in the nominated specialty, indicating that some secondary schools in particular experience difficulty recruiting teaching staff. In total, there were some 900 unfilled mathematics, science and technology positions at the time of the survey identified in 2011 (McKenzie et al, *op cit*.). Harris et al (2005) report concerns regarding supply of suitably qualified secondary science teachers:

> There is concern of the heads of secondary school science departments at the difficulty in recruiting suitably qualified staff, especially in light of the age profile of existing staff: more than one third of male science teachers are at least 50 years of age. (p. viii)

In the past, teacher skills shortages, particularly with respect to secondary qualified science teachers, have been identified as a key element of the ‘crisis in science education’ (Tytler, 2007[104]). The Australian Mathematical Sciences Institute (AMSI) has indicated that ‘a concerted and immediate effort by governments, the teaching profession and the universities is required to guarantee the supply of suitably qualified mathematics teachers’ (2012, n.p.[105]). Further, AMSI notes that ‘available teaching positions in Mathematics are more likely to remain unfilled than any other teaching positions: even though the situation in 2010 was slightly better than 2007, mathematics teaching positions remain the most difficult to fill’ (2013, n.p.[106]).

Whilst research from a decade ago indicated that shortages in secondary mathematics, science (physics and chemistry in particular) and technology had been persistent, and recruitment difficulties had been exacerbated in rural and remote locations (Department of Education, Science and Training, 2003[107]) it would appear that the extreme shortages

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[104] Tytler, R 2007, *Re-imaging Science Education Engaging students in science for Australia’s future*, Australian Education Review, Australian Council for Educational Research (ACER) Press, Victoria.

[105] Australian Mathematical Sciences Institute 2012, *Forum Communique* (press release), AMSI, Melbourne.

[106] Australian Mathematical Sciences Institute 2013, *Discipline profile of the mathematical sciences 2013.*

[107] Department of Education, Science and Training 2003, *Australia’s Teachers: Australia’s Future: Advancing Innovation, Science, Technology and Mathematics Main Report*, Australian Government, Canberra, viewed 7 January 2013, http://research.acer.edu.au/cgi/viewcontent.cgi?filename=2&article=1000&context=tll_misc&type=additional&sei-redir=1&referer=http%3A%2F%2Fwww.google.com.au%2Furl%3Fsa%3Dt%26rct%3Dj%26q%3Daustralia%25E2%2580%2599s%2520teachers%253A%2520australia%25E2%2580%2599s%2520future%26source%3Dweb%26cd%3D2%26ved%3D0CDgQFjAB%26url%3Dhttp%253A%252F%252Fresearch.acer.edu.au%252Fcgi%252Fviewcontent.cgi%253Ffilename%253D2%2526article%253D1000%2526context%253Dtll_misc%2526type%253Dadditional%26ei%3DDEnuUPGqO8L0kQWhsYCgDg%26usg%3DAFQj

have to some extent been addressed. More recent research conducted by the Department of Education, Employment and Workforce Relations (DEEWR) found that:

> Most teaching labour markets are adequately supplied. Employers advertising for school teachers in 2011-12 experienced little difficulty recruiting, generally attracting multiple suitable applicants and filling all but a small number of vacancies. (DEEWR, 2012f, p. 23)

The Department of Education, Employment and Workplace Relations aggregated *Skills Shortage List Australia 2011-12* (current as at June, 2012) only identified national skills shortages for the education professionals classification of Early Childhood (Pre-primary School) Teacher (DEEWR, 2012a[108]). National skills shortages are not listed for primary school teachers, secondary school teachers or vocational education teachers, although DEEWR does concede that 'secondary school teacher positions in the fields of senior mathematics and science attract relatively few suitable applicants' (p. 23). However, variation is reported at the state and territory level. Recruitment difficulties have been recorded in New South Wales for secondary school teachers in some locations (DEEWR, 2012b[109]), Queensland for primary school teachers in regional areas (DEEWR, 2012c[110]), Tasmania for mathematics and science teachers (DEEWR, 2012d[111]) and the Northern Territory for primary school and secondary school in mathematics and IT, particularly in remote locations (DEEWR, 2012e[112]). Schools located in regional and remote areas, or Indigenous communities, and schools with a low socioeconomic advantage experience more difficulty filling teaching vacancies (DEEWR, 2012f). Again the Australian Mathematical Sciences Institute cautions against complacency regarding teacher supply: 'the ageing secondary teacher population and falling graduation rates indicate an endemic problem' (AMSI, *op cit.,* p. 2).

Where there are unfilled positions, secondary school principals report implementing strategies including 'requiring teachers to teach outside their field of expertise' (42.2 per cent), 'recruit(ing) retired teachers on short-term contracts' (25.1 per cent), and 'recruit(ing) teachers not fully qualified in subject areas with acute shortages' (23.0 per cent). Again there were variations between school systems with more secondary school principals from government (72.9 per cent) than Catholic (67 per cent) or independent schools (49.3 per cent) resorting to a range of strategies to deal with staffing shortages (McKenzie et al, op cit.). As such, where there are labour market shortages in specialist science, mathematics and technology secondary school teaching positions, government and catholic schools in particular are resorting to sourcing under-qualified, or indeed unqualified replacement staff.

Centralisation of staffing arrangements – government schools

In government school systems, 'salary fixing and conditions systems, (and) … centralised employment and payment conditions' are centralised (Keating et al, *op cit.,* p. 16), whilst there is some flexibility regarding the selection of school staff. There is greater

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108 Department of Education, Employment and Workplace Relations 2012a, *Skills Shortage List Australia,* DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

109 Department of Education, Employment and Workplace Relations 2012b, *Skills Shortages New South Wales,* DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

110 Department of Education, Employment and Workplace Relations 2012c, *Skills Shortages Queensland*, DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

111 Department of Education, Employment and Workplace Relations 2012d, *Skills Shortages Tasmania*, DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

112 Department of Education, Employment and Workplace Relations 2012e, *Skills Shortages Northern Territory*, DEEWR, Canberra, viewed 7 January 2013, http://deewr.gov.au/skill-shortages.

flexibility in the Catholic and independent school systems in terms of staffing arrangements and conditions of employment.

Teaching standards

The Australian Institute for Teaching and School Leadership (AITSL) developed the *Australian Professional Standards for Teachers*. The standards 'define the work of teachers and make explicit the elements of high-quality, effective teaching in 21st-century schools, which result in improved educational outcomes for students' (AITSL, n.d.[113]).
The seven *Australian Professional Standards for Teachers* span three areas: professional knowledge, professional practice and professional engagement as follows:

Professional knowledge	1. Know students and how they learn
	2. Know the content and how to teach it
Professional practice	3. Plan for and implement effective teaching and learning
	4. Create and maintain supportive and safe learning environments
	5. Assess, provide feedback and report on student learning
Professional engagement	6. Engage in professional learning
	7. Engage professionally with colleagues, parents/carers and the community (AITSL, n.p.[114])

Each standard has a descriptor for the four teaching career stages – Graduate, Proficient, Highly Accomplished and Lead. *Graduate Standards* will underpin teacher education programs offered by providers throughout Australia. *Proficient Standards* will provide the basis for registration with each state and territory registration authority. *Highly Accomplished Standards* and *Lead Standards*, will provide the basis for voluntary certifications for more experienced teachers.

The Standing Council of School Education and Early Childhood (SCSEEC) endorsed national certification of Highly Accomplished and Lead teachers (April, 2012) where:

> National certification based on the Australian Professional Standards for Teachers is voluntary and will ensure that teachers, in every system and sector, have access to a rigorous and transparent process that recognises Highly Accomplished and Lead teachers and is portable throughout Australia. Certification of Highly Accomplished and Lead teachers has three primary purposes:
> . recognise and promote quality teaching
> . provide an opportunity for teachers to reflect on their practice
> . provide a reliable indication of quality teaching that can be used to identify, recognise and/or reward Highly Accomplished and Lead teachers (AITSL, n.p.[115])

LABOUR MARKET

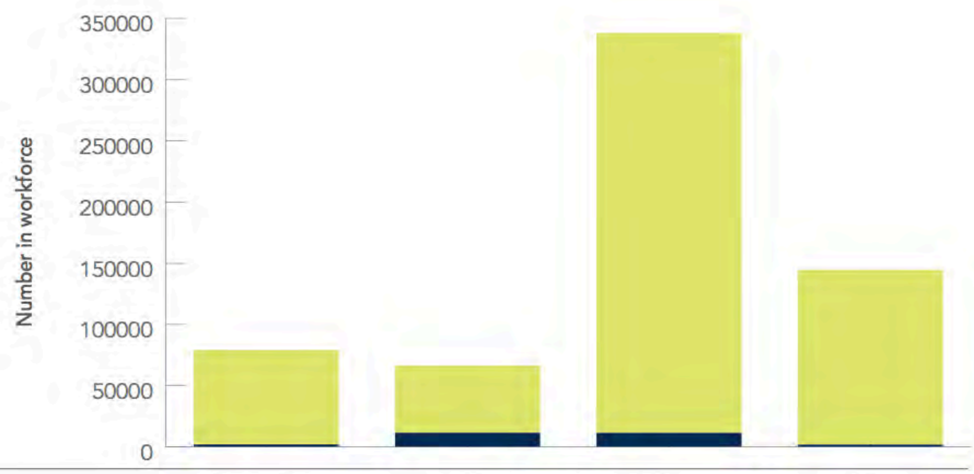
PARTICIPATION

AUSTRALIAN SCIENCE WORKFORCE

[113] Australian Institute for Teaching and School Leadership 2012, *Purpose of the standards* (webpage), viewed 28 December 2012, http://www.teacherstandards.aitsl.edu.au/Overview/Purpose.
[114] Australian Institute for Teaching and School Leadership 2012, *Australian Professional Standards for Teachers,* AITSL, viewed 5 March 2013, http://www.aitsl.edu.au/verve/_resources/The_7_Standards.pdf.
[115] Australian Institute for Teaching and School Leadership 2012, *Certification of Highly Accomplished and Lead Teachers in Australia*, AITSL (webpage), viewed 5 March 2013, http://www.newsroom.aitsl.edu.au/blog/teacher-certification.

Australia's STEM-related workforce totals approximately 627,000. This includes a large number in Health (approximately 338,000), followed by ICT (144,000), Engineering (79,000) then Natural and Physical Sciences (66,500). Doctorate holders in the STEM-related workforce are concentrated in Natural and Physical Sciences (11,433) and Health (11,325) (ABS, 2006 cited in the Office of the Chief Scientist, *op cit*.).

Figure 18: Number of science-related professionals in the workforce, 2006



	Engineering	N&PS	Health	ICT
Other	77074	55005	326777	142832
Doctorate	1849	11433	11325	1712

Source: Australian Bureau of Statistics, 2006 census data.

Source: Office of the Chief Scientist, 2012, *Health of Australian Science*, p. 38.

In addition to STEM-specific employees, many university graduates holding STEM-related qualifications are employed in non-STEM related fields. It is noted that in some instances, the ABS census data may result in under-reporting of STEM-qualified, or STEM-related workforce participation data (given the nature of self-reporting responses, and reporting of highest level qualification).

SHORTAGES

National skills shortages

National skills shortages have been identified by the Department of Education, Employment and Workplace Relations (DEEWR) in the *Skills Shortage List Australia 2011-12* (2012[116]) for the following STEM-related management and professional positions:

- Management (engineering manager)
- Design, Engineering, Science and Transport Professionals (surveyor, civil engineering professional, quantity surveyor, electrical engineer, mechanical engineer, mining engineer, petroleum engineer, agricultural consultant/scientist, geologist, geophysicist) and
- Health Professionals (sonographer, optometrist, audiologist, midwife).

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116 Department of Education, Employment and Workplace Relations 2012, *Skills Shortage List Australia 2011-12*, DEEWR, Canberra, viewed 29 December 2012, http://deewr.gov.au/skill-shortages.

In addition, national skills shortages have been reported in STEM-related paraprofessional technical and trade positions, including:

- Engineering, ICT and Science Technician positions (civil engineering draftsperson and technician, electrical engineering draftsperson and technician, mine deputy, and radio-communications technician)
- Automotive and Engineering Trades Workers (metal fabricator, metal machinist first class).

Shortages in engineering professional positions, in particular, are widespread (Skills Australia, 2011[117]). Difficulties in recruiting civil engineering professionals, in particular, have been experienced (Kaspura, 2011)[118]. Employers have reported experiencing difficulty attracting applicants with the requisite qualifications *and* several years relevant experience:

> In 2011-12, employers attracted a strong response to advertised vacancies (with 15.3 applicants per vacancy on average), but very few applicants were considered by employers to be suitable for the vacancies (on average there were 1.5 suitable applicants per vacancy, or about 1 in 10 applicants).
> (DEEWR, 2012[119])

Difficulties were exacerbated for senior positions, whereas employers generally filled graduate positions with little difficulty (*ibid*.).

Population ageing (Australian Government, 2010[120]) will exacerbate demand for STEM graduates as the labour force shrinks.

National professional engineering-related skill shortages have been largely attributed to activity in the resources sector (Australian Workplace and Productivity Agency, 2012)[121] and infrastructure construction sector (Skills Australia, 2011)[122]. Projections suggest that national professional engineering-related skill shortages will continue (Deloitte Access Economics, 2011)[123], and the supply of para-professional engineering graduates is insufficient to meet industry demand (Watson and McIntyre, 2011)[124]. The Australian Mathematical Sciences Institute predicts that 'demand for mathematics and statistics PhD graduates is tipped to increase by 55% from 2008 across all sectors of the Australian economy by 2020. Meeting this demand is hampered by an aging population of highly qualified mathematical scientists and a steady but inadequate PhD graduation rate' (AMSI, *op cit.,* p. 11).

The Australian Workforce and Productivity Agency has also identified high value, specialised occupations with anticipated shortages in their *Specialised Occupation List*

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117 Skills Australia 2011, *Interim Report on Resources Sector Skill Needs*, Australian Government, Canberra.

118 Kaspura, A 2011, *The Engineering Profession: A Statistical Overview, Eighth Edition, 2011*, Engineers Australia.

119 Department of Employment, Employment and Workplace Relations 2012, *Labour Market Research – Engineering Professionals and Associates*, DEEWR, Canberra, viewed 10 January 2013, http://deewr.gov.au/engineering-professions-and-associates-occupational-reports.

120 Australian Government 2010, *Australia to 2050: future challenges,* Australian Government, viewed 14 March 2013, http://archive.treasury.gov.au/igr/igr2010/report/pdf/IGR_2010.pdf.

121 Australian Workforce and Productivity Agency 2012, *Resources Sector Skills Needs*, Department of Industry, Innovation, Science, Research and Tertiary Education, Canberra, viewed 29 December 2012, http://www.awpa.gov.au/Pages/default.aspx.

122 Skills Australia 2011, *Engineering pathways seminar Background Paper*, viewed 29 December 2012, http://www.awpa.gov.au/events/documents/Engineering-Seminar-Background-Paper.pdf.

123 Deloitte Access Economics 2011, *Skill shortages in the resources sector*, Skills Australia, Canberra.

124 Watson, L & McIntyre, J 2011, *Scaling up: building engineering capacity through education and training*, University of Canberra, Canberra.

(SpOL)[125]. The 2012 list identified shortages for the following STEM-related occupations: engineering managers, surveyors and spatial scientists, engineers (chemical and materials, civil, electrical, industrial mechanical and production, mining, other), agricultural and forestry scientists, chemists, medical laboratory scientists, meteorologists, physicists (2011 only), ICT business and systems analysts, software and applications programmers, civil and electronic engineering draftspersons. In addition, the 2012 *Specialised Occupation List* (SpOL) also identified shortages for teachers (early childhood, primary, middle school, secondary and special education), and university lecturers and tutors.

Skills Australia (now the Australian Workforce and Productivity Agency) also developed a *Skilled Occupation List* (SOL) for the Commonwealth government's Department of Immigration and Citizenship General Skilled Migration Programme to 'augment the Australian labour supply with highly skilled workers from abroad without disrupting the balance of domestic labour and training markets, allowing for Australia to have the skill mix needed to maximise our growth potential' (AWPA, pp. 1-2[126]). The list criteria includes: long lead time to complete qualifications; high use (match between qualification and employment); and high risk to the community or economy associated with shortage. As such, a combination of Australian labour market and global immigration-based strategies are in place to seek to fill Australian STEM-related positions.

University staffing profile

There are also concerns regarding the Australian university academic staffing profile as the academic workforce ages, casualisation increases, working conditions exacerbate recruitment challenges, and global competition increases (Bradley et al., *op cit*). The Australian Mathematical Sciences Institute reports that teaching and research staff numbers for the Group of Eight (GO8) decreased by a third in the period 1995-2005 which is a particular concern for mathematics as the GO8 represents a large proportion of mathematical academic activity (AMSI, 2012[127]).

Low research staffing levels are notable in Environmental Sciences, Earth Sciences, Mathematical Sciences, Physical Sciences, Chemical Sciences, and Agricultural and Veterinary Sciences (ARC 2011, cited in the Office of the Chief Scientist, *op cit.*). Shortages are expected to worsen as current senior researchers (Level E) retire. These concerns have implications for the capacity of the university sector to enhance scientific literacy in the general student population, educate undergraduate and higher degree by research students in STEM disciplines, and undertake research in the STEM disciplines.

State-based labour market information

Brief information regarding South Australian and Victorian labour markets is provided below to illustrate projected shortages at the state level. The South Australian Premier's Science and Industry Council *Science, Research and Industry Innovation Strategy for South Australia: Consultation paper* (2012[128]) provides South-Australian specific information regarding anticipated STEM shortages.

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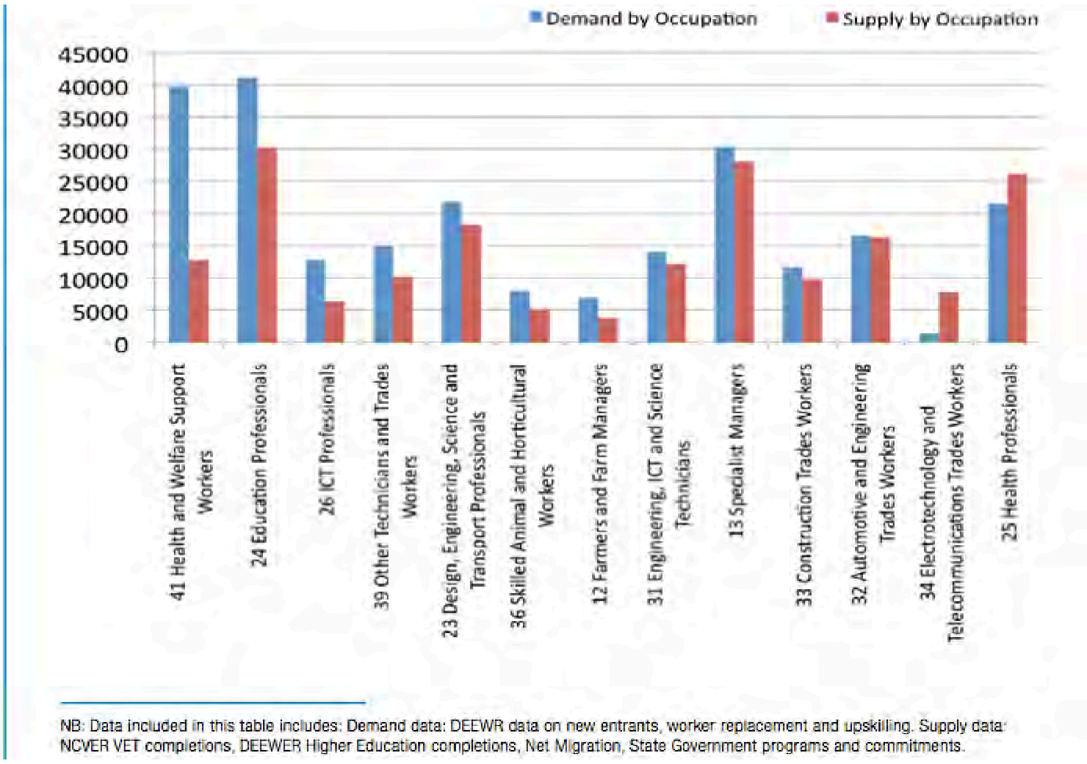
125 Australian Workforce and Productivity Agency 2012, *Specialised Occupation List (SpOL)*, DIISRTE, Canberra, viewed 30 December 2012, http://www.awpa.gov.au/our-work/labour-market-information/specialised-occupations-list/Pages/Specialised-Occupation-List-(SpOL)-2012.aspx.

126 Australian Workforce and Productivity Agency 2012, *Labour Market Information*, AWPA, Canberra, viewed 30 December 2012, http://www.awpa.gov.au/our-work/labour-market-information/Pages/default.aspx.

127 Australian Mathematical Sciences Institute 2012, *Discipline Profile of the Mathematical Sciences,* AMSI, Melbourne.

128 Science and Industry Council 2012, *Science, Research and Industry Innovation Strategy for South Australia,* South Australian Government, Adelaide, viewed 1 January 2013, http://www.dfeest.sa.gov.au/Portals/1/Documents/science/SRII%20Consultation%20paper%20-%20final%203%20Dec%2010.30am.pdf.

Figure 19: Demand and supply of occupations 2012-2012 (South Australia)



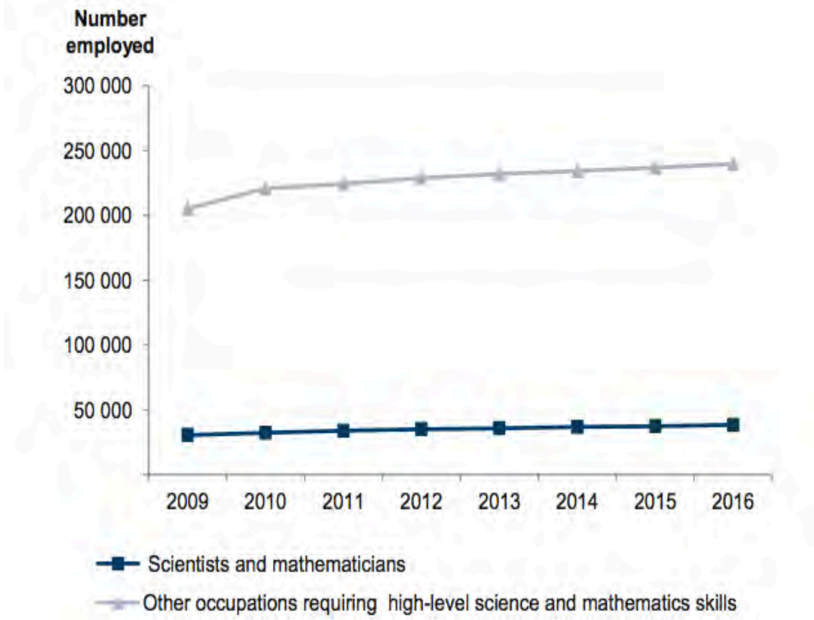
Source: Premier's Science and Industry Council 2012, *Research and Industry Innovation Strategy for South Australia: Consultation paper*, p. 8.

The paper projects unmet demand in several STEM fields (ICT Professionals; Design, Engineering, Science and Transport Professionals; Engineering, ICT and Science Technicians), and indeed projects unmet demand for almost all occupations (*ibid*, p. 7).

In Victoria, Monash University data demonstrates that demand for scientists and mathematicians grew over the period 2009-2011, and is projected to grow a further 14 per cent (7,900 positions) over the period 2011-2016. Similarly, demand for professionals with core scientific and mathematical skills grew over the period 2009-2011 and is projected to grow a further 7 per cent (34,700 positions) (Victorian Auditor-General, 2012[129], p. 1).

Figure 20: Demand for employees with science and mathematics skills in Victoria

[129] Victorian Auditor-General 2012, *Science and Mathematics Participation Rates and Initiatives*, Victorian Government, Melbourne, viewed 5 January 2013, http://www.audit.vic.gov.au/publications/20120606-science-and-maths/20120606-science-and-maths.pdf.

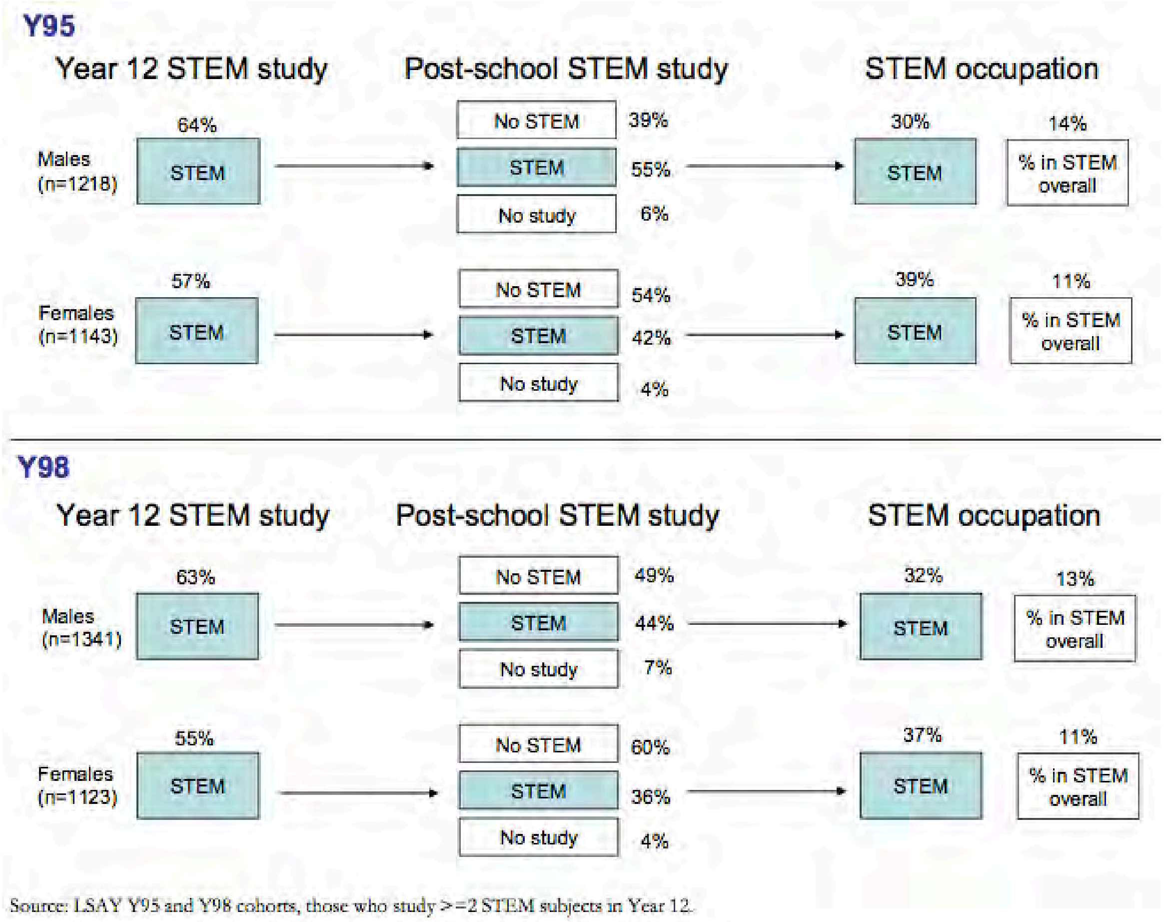


Source: Victorian Auditor-General 2012, *Science and Mathematics Participation Rates and Initiatives*, p. 1 based on Monash University Centre of Policy Studies data.

Transitions to STEM occupations

Analysis of data from the Longitudinal Surveys of Australian Youth (LSAY) by Anlezark et al. (2008) reveals the transitions of Year 12 STEM students from the 1995 and 1998 LSAY cohorts (referred to as Y95 and Y98, below), to post-school STEM study and STEM occupations. 64 per cent of the total cohort of *male* 1995 Year 12 students undertook two or more of science, mathematics or computing/information technology subjects. 55 per cent progressed to post-school STEM study and 30 per cent transitioned to a STEM-specific occupation (the figures for 1998 varied primarily with respect to the transition from Year 12 STEM study to post-school STEM study, but remained relatively constant in the transition to a STEM-specific occupation). For young males, there is leakage in the STEM pipeline from post-school STEM study to STEM-specific occupations, and this pattern is replicated for high mathematics achieving males (Anlezark et al, 2008).

Figure 21: Pathways into commencing post-school study and STEM occupations of those who study STEM subjects at school



Source: Anlezark, A et al. 2008, *From STEM to leaf: Where are Australia's science, mathematics, engineering and technology (STEM) students heading?* NCVER, p. 11[130].

For girls and women, 57 per cent of the total cohort of female 1995 Year 12 students undertook two or more of science, mathematics or computing/information technology subjects. 42 per cent progressed to post-school STEM study and 39 per cent transitioned to a STEM-specific occupation (again, the figures for 1998 varied primarily with respect to the transition from Year 12 STEM study to post-school STEM study, but remained relatively constant in the transition to a STEM-specific occupation). For young females, there is leakage in the STEM pipeline from Year 12 STEM study to post-school STEM study, and this pattern is replicated for high mathematics achieving females (Anlezark et al, 2008). This suggests that attention needs to be given to the transitions for young males into STEM occupations following STEM study, whereas attention should be focused on transitions for young females into post-school STEM study following Year 12 science and mathematics study.

Further, Anlezark et al. confirm that the pipeline is primarily linear (that is, people progress into a STEM-specific occupation having completed Year 12 STEM subjects, then post-school STEM study), such that 'very few people who work in STEM occupations have not undertaken any prior STEM study in Year 12 or post-school' (2008, p. 17).

[130] Anlezark, A, Lim, P, Semo, R & Nguyen, N 2008, *From STEM to leaf: Where are Australia's science, mathematics, engineering and technology (STEM) students heading?* NCVER, viewed 25 February 2013, http://www.innovation.gov.au/Skills/ResourcesAndPublications/Documents/STEMtoLeafAustSciTechEnginMathHeading.pdf.

RESEARCH AND INNOVATION

Gross expenditure on research and development (GERD)

2008-2009 gross expenditure on science-related research and development totalled $24.6 billion, which represented 91 per cent of total gross expenditure on research and development (GERD) ($27.7 billion) (Research and Experimental Development Tables, ABS cited in Office of the Chief Scientist, *op cit.,* p. 28). This included both government and business expenditure, and represented 2.2% GDP. Australia ranked 14th on this OECD measure of research intensity, behind Israel, Finland, Sweden, Japan, Korea, Switzerland, Denmark, United States, Chinese Taipei, Germany, Austria and Singapore. Commonwealth expenditure accounted for some 30 per cent of GERD, with business contributing the majority towards science-related research and development. There was much variation between science-related disciplines, with Engineering receiving by far the bulk of funding ($10.3 billion), followed by Information & Computing Sciences ($4.9 billion) then Medical & Health Sciences.

The majority of research and development expenditure is allocated to applied research (80 per cent), with the remainder allocated to basic research. The Commonwealth funds the vast majority (approximately 75 per cent) of all basic research, primarily through the university sector. There is much variation in the relative Commonwealth / business / higher education sector contribution to GERD between science-related fields of research.

Commonwealth funding on science is primarily through the portfolio research agencies (the Commonwealth Scientific and Industrial Research Organisation, the Defence Science and Technology Organisation, the Australian Nuclear Science and Technology Organisation, the Australian Institute of Marine Science, and Geoscience Australia) and competitive grant schemes under the Australian Research Council, National Health and Medical Research Council and Co-operative Research Centres program. The *Health of Australian Science* reports that 'expenditure through CSIRO rose 9.5 per cent, and through DSTO it rose 25 per cent. Appropriations to ANSTO fell 20 per cent, and those to AIMS and GA were essentially unchanged' (p. 167).

GOVERNMENT: STRUCTURES, POLICIES, STRATEGIES AND REPORTS

STRUCTURES

Prime Minister's Science, Engineering and Innovation Council (PMSEIC)

The Prime Minister's Science, Engineering and Innovation Council (PMSEIC) was established in 1998 as the peak science and engineering advisory body to the Commonwealth government. The terms of reference of the PMSEIC are:

- To advise on important issues of science and technology, broadly defined, including issues related to Australia's economy, public good, education, future industries and employment, security, and sustainable development in a modern world
- To undertake a key foresighting role, anticipating and reporting upon likely or emerging needs of, threats to, or opportunities for Australia and its people that may benefit from a response grounded in scientific evidence or technological innovation
- To assist in the evolution of Governmental research and innovation priorities by identifying any gaps that are uncovered in the foresighting role
- To advise on the adequacy and effectiveness of Australia's resources and infrastructure for supporting science, technology and its innovative use for the benefit of Australia

- To enhance awareness in the community of the importance of science and technology to Australia's economic and social development. (DIISRTE, 2012)[131]

The membership, restructured in early 2012, includes the Prime Minister (chair), Minister for Tertiary Education, Skills, Science and Research, Minister for Industry and Innovation, other relevant Ministers, Australia's Chief Scientist, the CEOs of the Australian Research Council and National Health and Medical Research Council, and six individual members.

Chief Scientist for Australia

Australia's Chief Scientist advises the government on matters relating to science, technology and innovation, advocates Australian science, and engages with the Australian community (Australia's Chief Scientist, 2012[132]). Australia's Chief Scientist is a member of the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), participates in the Forum of Australian Chief Scientists, and commissions long term projects through the Australian Council of Learned Academies (ACOLA). Australia's Chief Scientist is currently Professor Ian Chubb AC.

The Australian Council of Learned Academies (ACOLA)

The Australian Council of Learned Academies (ACOLA) comprises The Australian Academy of Science, The Australian Academy of Technological Sciences and Engineering, The Academy of the Social Sciences in Australia and The Australian Academy of the Humanities. ACOLA 'provides the forum for the four Learned Academies to work cooperatively to develop cutting-edge thinking and integrated problem solving. ACOLA'S purpose is to harness expert knowledge from multiple disciplinary perspectives, to inform national policy and to develop innovative solutions to complex global problems and emerging national needs' (ACOLA, 2012[133]).

Australian State and Territory Chief Scientists

Several Australian states and territories have established Chief Scientist, or equivalent, positions. The Queensland Chief Scientist provides the Queensland government with 'high level, strategic advice … on the role of science, research and innovation in meeting Queensland's economic challenges' (Office of the Queensland Chief Scientist, 2012[134]). The Queensland Chief Scientist chairs the R&D Queensland committee. The New South Wales Chief Scientist and Engineer provides the New South Wales government with advice regarding science, engineering and research[135], and participates in the NSW Innovation and Productivity Council. The Victorian government has had a Joint Chief Scientist arrangement. In 2011, the Victorian Premier announced the establishment of the Office of the Lead Scientist (Baillieu, 2011[136]).

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[131] Department of Industry, Innovation, Science, Research and Tertiary Education 2012,*The Prime Minister's Science, Engineering and Innovation Council (PMSEIC)* (webpage), DIISRTE, Canberra, viewed 30 December 2012, http://www.innovation.gov.au/science/pmseic/Pages/default.aspx.

[132] Office of the Chief Scientist 2012, *The Chief Scientist* (website), Australian Government, Canberra, viewed 30 December 2012, http://www.chiefscientist.gov.au/about/the-chief-scientist/.

[133] Australian Academy of Learned Academies 2012, *Strategic Statement 2010-2012*, ACOLA, Melbourne, viewed 8 January 2013, http://www.acolasecretariat.org.au/ACOLA2011/Strategic_Statement_2010-2012.html.

[134] Office of the Queensland Chief Scientist 2012, *About the Queensland Chief Scientist* (webpage), Queensland Government, Brisbane, viewed 30 December 2012, http://www.chiefscientist.qld.gov.au/about.aspx.

[135] NSW Government Chief Scientist & Engineer 2012, *About Professor Mary O'Kane* (webpage), NSW Government, Sydney, viewed 30 December 2012, http://www.chiefscientist.nsw.gov.au/about.

[136] Baillieu, T 2011, *Coalition delivers $7.9 million to drive innovation through technology* (press release), Victorian Government, viewed 30 December 2012, http://www.premier.vic.gov.au/media-centre/media-releases/720-coalition-delivers-79-million-to-drive-innovation-through-technology.html.

The Chief Scientist for South Australia advises the South Australian government on 'science and research, technology and innovation' (Department of Further Education, Employment, Science and Technology[137]). The Chief Scientist for South Australia participates in the Premier's Science and Industry Council (PSIC), and is based in the government Department of Further Education, Employment, Science and Technology (DFEEST). The Chief Scientist for Western Australia advises the Western Australian government on science and innovation[138] and participates in the Technology and Industry Advisory Council (TIAC). The Office of the Chief Scientist is located in the government Department of Commerce. A Victorian Joint Chief Scientist has chaired the Tasmanian government Science and Research Industry Advisory Committee[139]. As such, there are variations with respect to Chief Scientist positions in terms of the primary functions: government science and technology spokesperson, government advisor, reviewer, champion (Mitchell, reported in Bildstein, 2003[140]), human resources (that is, full/part-time or not established), location of the offices within the machinery of government, involvement with STEM-related government advisory committees, and emphases (DIISR, 2011[141]; Bildstein, *op cit*.).

Table 16: Summary of Commonwealth, state and territory policies, reports and strategies

COMMONWEALTH / STATE / TERRITORY POLICIES AND REPORTS	**STRATEGIES**
Prime Minister's Science, Engineering and Innovation Council (PMSEIC)	- peak science and engineering advisory body to the Commonwealth government
Australia's Chief Scientist	- advise the government on matters relating to science, technology and innovation - advocate Australian science - engage with the Australian community
Australian Council of Learned Academies (ACOLA)	- forum for the four Learned Academies (science, technological sciences and engineering, social sciences, humanities)
State and territory chief scientists and science committees	- Queensland Chief Scientist (R&D Queensland committee) - New South Wales Chief Scientist and Engineer (Innovation and Productivity Council) - Joint Chief Scientist - Chief Scientist for South Australia (Premier's Science and Industry Council) - Chief Scientist for Western Australia (Technology and Industry Advisory Council) - Victorian Joint Chief Scientist chairs the Tasmanian Science and Research Industry Advisory Committee

137 Department of Further Education, Employment, Science and Technology 2012, *Chief Scientist for South Australia* (webpage), DFEEST, viewed 30 December 2012, http://www.dfeest.sa.gov.au/science-research/chief-scientist-for-south-australia.

138 Department of Commerce 2012, *Chief Scientist of WA* (webpage), Government of Western Australia, viewed 30 December 2012, http://www.commerce.wa.gov.au/scienceinnovation/Content/About_Us/Our_partners/WA_Chief_Scientist.html.

139 O'Byrne, D 2012, *Growing Jobs and Opportunities in Science and Research* (press release), Tasmania Government, viewed 30 December 2012, http://www.premier.tas.gov.au/media_room/media_releases/growing_jobs_and_opportunities_in_science_and_research.

140 Bildstein, T 2003, *Chief Scientist Calling for Tasmania* (press release), viewed 30 December 2012, http://lists.asc.asn.au/pipermail/asc-list/2003-August/000560.html.

141 Department of Innovation, Industry, Science and Research 2011, *Focusing Australia's Publicly Funded Research Review: Maximising the innovation dividend review key findings and future directions,* DIISR, Canberra, viewed 30 December 2012, http://www.innovation.gov.au/Research/Documents/ReviewAdvicePaper.pdf.

GOVERNMENT REPORTS AND POLICY STATEMENTS

SCHOOLING AND TEACHING QUALITY

Melbourne Declaration on Educational Goals for Young Australians (2008)

The *Melbourne Declaration on Educational Goals for Young Australians* (Ministerial Council on Education, Employment, Training and Youth Affairs[142]) was agreed by Commonwealth, state and territory education ministers in December 2008. The *Melbourne Declaration* established requirements for all Australian school students to develop knowledge in English, mathematics, science (physics, chemistry and biology), languages, humanities and the arts. The *Melbourne Declaration* identified literacy and numeracy, mathematics and English as foundation skills, and stated that practical skills such as information communication technology (ICT), and design and technology are 'central to Australia's skilled economy and provide crucial pathways to post-school success' (p. 13). The *Melbourne Declaration* committed all Australian governments to quality schooling.

Measurement Framework for Schooling in Australia (2010) and National Assessment Program – Literacy and Numeracy (NAPLAN)

The *Measurement Framework for Schooling in Australia* (Ministerial Council for Education, Early Childhood Development and Youth Affairs, 2010[143]) provides the framework for assessment of performance against goals established in the *Melbourne Declaration on Educational Goals for Young Australians*. The National Assessment Program[144] forms a key component of the Measurement Framework, and involves assessing school students' performance in literacy and numeracy, science, civics and ICT.

The National Assessment Program comprises the annual NAPLAN, Sample Assessments in science literacy, civics and citizenship and ICT literacy, and international sample assessments including PISA and TIMSS. In 2011, Australia also participated in the Progress in International Reading Literacy Study (PIRLS) for the first time.

In terms of sample and timing, NAPLAN assesses all Australian students in Years 3, 5, 7 and 9 on an annual basis. The Sample Assessments assess a sample of Australian students on a three-yearly basis. For example, the *National Assessment Program - Science Literacy* (NAP-SL) assesses Year 6 student scientific literacy whereas the National Assessment Program – Information & Communication Technology Literacy (NAP-ICTL) assesses Years 6 and 10 student ICT literacy. PISA is undertaken by the OECD on a three-yearly basis, involving 15 year old school students. TIMSS is undertaken by the International Association for the Evaluation of Educational Achievement (IEA) on a four yearly basis, involving Years 4 and 8 school students whilst PIRLS is undertaken by the IEA on a five yearly basis and involves students in their fourth year of school education. The IEA also implements TIMSS Advanced, which 'assesses student achievement in advanced mathematics and physics in the final year of secondary school—the twelfth grade in many countries' (IEA, 2012[145]). The next TIMSS Advanced surveys will be conducted in 2015, however Australia has not agreed to participate at this stage.

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142 http://www.mceecdya.edu.au/verve/_resources/national_declaration_on_the_educational_goals_for_young_australians.pdf

143 http://www.acara.edu.au/verve/_resources/Measurement_Framework_for_Schooling_in_Australia_2010.pdf

144 http://www.nap.edu.au/

145 International Association for the Evaluation of Educational Achievement 2012, *About TIMSS Advanced 2008*, viewed 5 March 2013, http://timssandpirls.bc.edu/timss_advanced/index.html.

As such, there is a comprehensive program of science, mathematics and technology performance testing in place. These assessments are, however, not without criticism: 'NAPLAN may be having a detrimental effect in areas such as curriculum breadth, pedagogy, staff morale, schools' capacity to attract and retain students and student well-being' (Dulfer, Polesel & Rice, 2012, p. 9[146]).

Review of Teaching and Teacher Education (2003)

Australia's Teachers: Australia's Future: *Advancing Innovation, Science, Technology and Mathematics* (DEST, 2003[147]) is the three-part report of the Committee for the Review of Teaching and Teacher Education established under the former Commonwealth government's *Backing Australia's Ability: An Innovation Action Plan for the Future*[148]. Two other volumes complement the main report: *Agenda for Action,* which presents conclusions and recommends strategies, and *Background Data and Analysis.* The main report stated that:

> policies and strategies are required to ensure a broad base of scientific, mathematical and technological literacy for all students. This means that science, technology and mathematics education must be given high priority nationally, and in all education systems and every school (DEST, *op cit*., p. xviii).

The Review of Teaching and Teacher Education found declining student participation in senior secondary science, teacher supply issues (science, technology, mathematics), teacher qualification issues (primary school science), concerns regarding student engagement and participation disparities for specific student cohorts (such as Indigenous students) (*ibid.*, p. xviii). The main report reaches the conclusion that, amongst other things:

> Australia needs:
> - to ensure that through its educational systems there are in place personnel, procedures and resources for all Australians to become scientifically, mathematically and technologically literate;
> - to take more direct measures to equip itself with world-class scientists and innovators;
> - to enhance national capacity to recruit, train, reward and retain world-class teachers of science, technology and mathematics (p. 61).

The *Agenda for Action* (DEST, 2003[149]) recommended a series of priority areas including 'energising the sciences and technology, and prioritizing innovation in schools; planning and collaboration to attract and retain quality teachers; revitalizing the teaching profession; strengthening teacher education and professional learning; (and) supporting future schools through leadership, teams and partnerships' (p. 2), which it depicted as follows:

Figure 22: An Agenda for Action priorities

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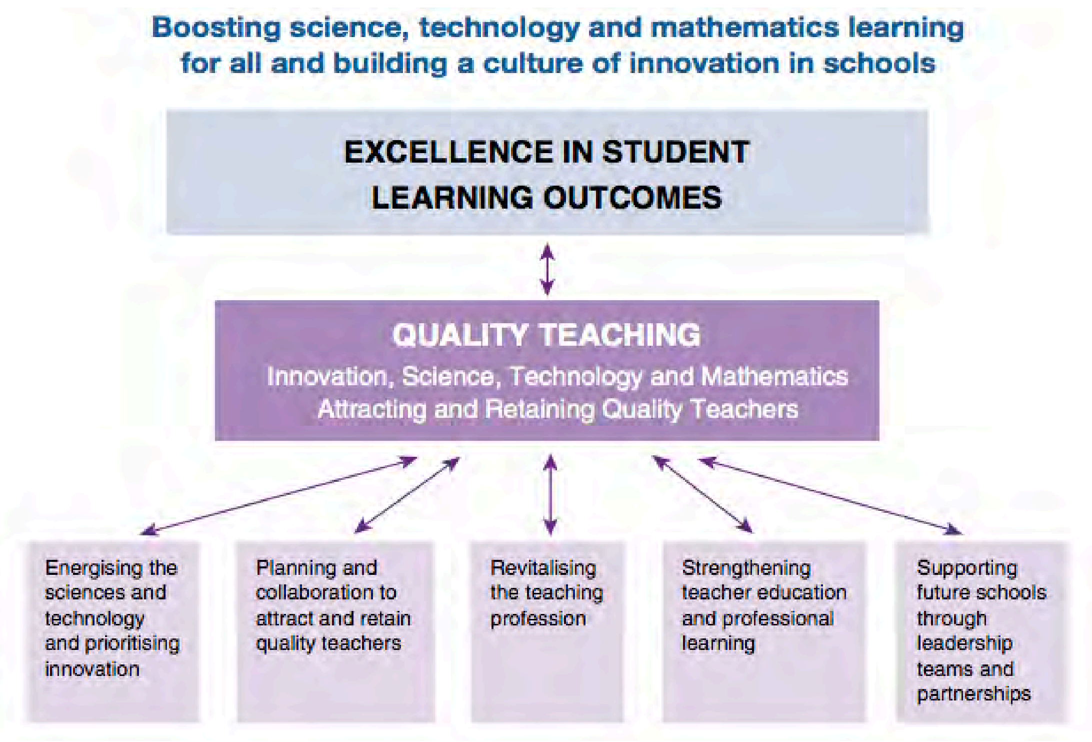
[146] Dulfer, N, Polesel, J & Rice, S 2012, *The Experience of Education: The impacts of high takes testing on school students and their families An Educator's Perspective,* The Whitlam Institute, Sydney, viewed 8 January 2013, http://www.whitlam.org/__data/assets/pdf_file/0010/409735/High_Stakes_Testing_An_Educators_Perspective.pdf.

[147] Department of Education, Science and Training 2003, *Australia's Teachers: Australia's Future*: *Advancing Innovation, Science, Technology and Mathematics,* Australian Government, Canberra, viewed 28 December 2012, http://research.acer.edu.au/tll_misc/1/.

[148] Commonwealth of Australia 2001, *Backing Australia's Future: An Innovation Action Plan for the Future*, Australian Government, Canberra, viewed 28 December 2012, http://www.austms.org.au/Jobs/backing_Aust_ability.pdf.

[149] Department of Education, Science and Training 2003, *Agenda for Action,* Australian Government, Canberra, viewed 28 December 2012, http://research.acer.edu.au/cgi/viewcontent.cgi?filename=0&article=1000&context=tll_misc&type=additional.



Source: DEST, 2003, *An Agenda for Action*, p. 2.

Strategies, or 'actions' recommended in the report with respect to enhancing disciplinary expertise include the following:

- the creation of a national network of local and regional science clusters linking schools and teachers with science organisations, tertiary education institutions and industry organisations …;
- limited term teacher placements in science, technology or mathematics- related jobs beyond their schools …;
- substantial professional learning opportunities for teachers of science, technology and mathematics …;
- the forging of interdisciplinary links among, and multi-disciplinary approaches to, science, mathematics, technology and other learning areas …; and
- visits or short exchanges to other schools by highly competent and committed school leaders and teachers capable of acting as agents of change in their own or other schools. (p. 10)

National Partnership Agreement on Improving Teacher Quality (2008) and Australian Professional Standards for Teachers

The Council of Australian Governments (COAG) developed a *National Partnership Agreement on Improving Teacher Quality* (2008) between the Commonwealth and state and territory governments. The national partnership agreement:

> aims to deliver system-wide reforms targeting critical points in the teacher "lifecycle" to attract, train, place, develop and retain quality teachers and leaders in our schools

> and classrooms. It also has a specific focus on professional development and support for principals (2008, p. 4[150]).

The national partnership agreement allocated $550 million, with states and territories directly allocated $481.6 million for the period 2008-09 – 2012-13 and $68.4 retained by the Commonwealth.

Table 17: Funding allocated to the National Partnership Agreement on Improving Teacher Quality (by State/Territory)

NSW	VIC	QLD	SA	WA	TAS	NT	ACT	Total
$154.1m	$122.4m	$95.2m	$35.2m	$48.9m	$11.4m	$5.9m	$8.6m	$481.6m
32.0%	25.4%	19.8%	7.3%	10.1%	2.4%	1.2%	1.8%	100%

Source: DEEWR data, unpublished

The *National Partnership Agreement on Improving Teacher Quality* supported the development of the *Australian Professional Standards for Teachers* by the Australian Institute for Teaching and School Leadership (AITSL). The *National Partnership Agreement on Improving Teacher Quality* also supported national accreditation of initial teacher education courses (in accordance with the AITSL Graduate Standards), national consistency in teacher registration (in accordance with the AITSL Proficient Standards), performance management systems (that is, strategies for highly accomplished and lead teacher reward and retention) and professional development for teachers, principals and school leaders. The agreement also supported Teach for Australia, enhanced teacher data collection and increased support for teachers, school leaders and principals working in rural and remote areas, and disadvantaged Indigenous schools[151] (DEEWR, 2012).

In addition, the Commonwealth funded the *Quality Teaching Package for Enhancing Literacy* under the *Closing the Gap in the Northern Territory National Partnership* ($44.3 million over the period 2009-10 to 2011-12). This package focused on enhancing education qualifications and career pathways for Indigenous staff, and addressing literacy and numeracy in remote Northern Territory communities.

Review of Funding for Schooling: Final Report (2011) (Gonski Report)

In 2010, the Commonwealth government commissioned a review of school education funding arrangements. The *Review of Funding for Schooling*: *Final Report* (2011)[152] (the Gonski Report) stated that:

> over the last decade the performance of Australian students has declined at all levels of achievement, notably at the top end. … In 2000, only one country outperformed Australia in reading and scientific literacy and only two outperformed Australia in mathematical literacy. By 2009, six countries outperformed Australia in reading and scientific literacy and 12 outperformed Australia in mathematical literacy (Gonski et al, 2011, p. xiii).

The review also found a growing gap between high and low performing students and ‘an unacceptable link between low levels of achievement and educational disadvantage, particularly among students from low socioeconomic and Indigenous backgrounds’ (Gonski et al, 2011, p. xiii). The report cited the various commitments to quality schooling, including the *Melbourne Declaration on Education Goals for Young Australians* and COAG *National Education Agreement*, and stated that ‘while these

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150 Council of Australian Governments 2008, *National Partnership Agreement on Improving Teacher Quality*, Australian Government, Canberra.

151 Department of Employment, Education and Workplace Relations 2012, *Smarter Schools National Partnership for Improving Teacher Quality Fast Facts,* DEEWR, Canberra, viewed 28 December 2012, http://foi.deewr.gov.au/node/30178.

152 Gonski et al. 2011, *Review of Funding for Schooling – Final Report*, Australian Government, Canberra.

reforms lay a good foundation for addressing Australia's schooling challenges, they need to be supported by an effective funding framework' (p. xiv). The review found a lack of coherence in school funding, an imbalance between Commonwealth and state and territory commitments across the sectors (government, Catholic, independent), and a lack of co-ordination in terms of policy and planning. Policies and strategies identified to address disadvantage include the National Partnership arrangements (*Smarter Schools – Literacy and Numeracy, Smarter Schools – Low SES School Communities, Closing the Gap in the Northern Territory, More Support for Students with Disabilities),* teaching quality initiatives, literacy and numeracy initiatives, local solutions, enhanced school leadership, community engagement and performance evaluation.

The review recommended a significant injection of funding into the school system. In addition, the review recommended implementation of a schooling resource standard to fund primary and secondary school students from all sectors, with loadings for disadvantaged students (socio-economic status, Indigenous, disability) and schools (size and location).

National Plan for School Improvement

Following the release of the *Review of Funding for Schooling: Final Report* the Commonwealth announced plans to introduce a fairer school funding model and the *National Plan for School Improvement*. On 19 November 2012 the Australian Government introduced into Parliament the *Australian Education Bill 2012*. The Bill establishes a national vision for schooling reform, based on the *National Plan for School Improvement*. The plan's central goal is:

> By 2025, Australian students will be in the top 5 in the world in reading, science and maths. By the same year, all Australian children will go to a school in a nation which is ranked in the top five in the world for high-quality and high-equity education (Commonwealth Government, 2012[153]).

The *Australian Education Bill 2012* confirms the Government's intention to introduce a fairer school funding model, based on the core recommendations of the *Review of Funding for Schooling: Final Report*. Under the Government's new school funding model, additional resources (loadings) will be allocated to schools based on the characteristics of students at that school. Disadvantaged schools (rural, remote and small) and disadvantaged students (low socio-economic status, Indigenous students, students with a disability and students with limited English proficiency) will attract extra funding.

The Plan will also support teaching quality-related initiatives under the Quality Teaching theme including increasing entry requirements for school leavers and mature-aged teaching degree entrants ('entrants to the teaching profession will be in the top 30 per cent of literacy and numeracy results' [Gillard, 2012][154]), increasing the length of initial teacher education practicum requirements, managing teacher performance against the *Australian Professional Standards for Teachers* and improvements to teacher and principal professional development. The Plan will also deliver increased authority for school principals in terms of financial and staffing decision-making.

NSW report – Great Teaching, Inspiring Learning: Discussion Paper (2012)

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153 Commonwealth of Australia 2012, *National Plan for School Improvement – FAQs*, Australian Government, Canberra, viewed 31 December 2012, http://www.schoolfunding.gov.au/node/148#how-long-will-it-take-to-implement.

154 Gillard, J 2012, *Better Schools: A National Plan for School Improvement* (press release 3 September 2012)*,* viewed 31 December 2012, http://ministers.deewr.gov.au/gillard/better-schools-national-plan-school-improvement.

With respect to entry to initial teacher education programs, the NSW government's *Great Teaching, Inspired Learning: Discussion Paper* (2012[155]) invited feedback regarding minimum Australian Tertiary Education Rank (ATAR) requirements and mathematics, science and English language pre-requisites for entry to initial teacher education programs. The NSW Institute of Teachers, Board of Studies and Department of Education have indicated they will recommend that higher entry requirements be established for primary education programs (90 per cent in Higher School Certificate mathematics and English) and secondary school education programs (90 per cent in the subject they will teach in) (Ferrari, *NSW to recruit smarter teachers*, 2012[156]). This proposal is currently being debated.

Science Engagement and Education: Equipping young Australians to lead us to the future (2003)

The report, *Science Engagement and Education: Equipping young Australians to lead us to the future* (2003) was prepared by the Prime Ministers Science, Engineering and Innovation Council (PMSEIC) Working Group on Science Engagement and Education. The report established one key goal of 'A science-literate society, through the engagement of young Australians in science, from primary school right through their educational years to their careers and lives' (Working Group on Science Engagement and Education, 2003, p. 4). *Science Engagement and Education* recognised the relationship between science-literacy and literacy and numeracy, stating that 'Australia must be science-literate, as well as having basic literacy and numeracy' (Working Group on Science Engagement and Education, p. 5). Variable science education in Australian primary schools was noted, as was decreasing participation in and engagement with secondary science, decreasing undergraduate university science participation, and discouraged teachers. The report recommended that science engagement and science literacy initiatives focus on the education of young Australians through science outreach programs, and deliver primary-school level science through literacy education. *Science Engagement and Education* also recommended the integration of science investigation pedagogies at the junior secondary level, partnerships between industry and education, and the consolidation of teaching quality.

Victorian government inquiry into mathematics and science (2006)

The Parliament of Victoria Education and Training Committee *Final Report: Inquiry into the Promotion of Mathematics and Science Education* (2006) found variability in school-level participation and achievement in mathematics and science (cohorts, based on socio-economic status, gender and geographical location; teaching quality; infrastructure and equipment). The report recommended increasing school-level participation and achievement in science and mathematics, and established a vision for 'a level of mathematical and scientific literacy that matches the best in the world by 2020 and to increase the proportion of our highest achievers pursuing these disciplines' (Parliament of Victoria, 2006, p. 1). Key recommendations concerned professional development for primary school teachers to increase confidence and capacity in delivering mathematics and science education, and support for secondary school science teachers (for example content expertise, contemporary science, strategies for student engagement). Recommendations also involved increasing senior secondary student participation in the enabling sciences (including addressing cohort disparities), the installation of

[155] New South Wales Government 2012, *Great Teaching, Inspired Learning: Discussion paper,* NSW Government, Sydney, viewed 31 December 2012, http://www.schools.nsw.edu.au/media/downloads/news/greatteaching/gtil.pdf.

[156] Ferrari, J 2012, *NSW to recruit smarter teachers,* The Australian, 26 December 2012, viewed 31 December 2012, http://www.theaustralian.com.au/national-affairs/education/nsw-to-recruit-smarter-teachers/story-fn59nlz9-1226543393881.

contemporary science equipment for primary and secondary science education, careers and subject selection advice and teacher supply and demand (*ibid*.).

Australian Mathematical Sciences Institute policy recommendations

The Australian Mathematical Sciences Institute report, *Maths for the Future: Keep Australia Competitive* (2012[157]) identified the key issues with respect to mathematics: 'demand for mathematical and statistical skills far outstrips falling supply, and maintaining Australia's international competitiveness, security, population health and climate stability requires a mathematically literate population' (2012). The Australian Mathematical Sciences Institute recommended a number of key policy interventions to rectify the decline in enrolments in intermediate and advanced Year 12 mathematics, including: awareness raising, reinstating mathematics prerequisites for engineering degrees, improved mathematics preparation for school mathematics teachers and primary school teachers, university scholarships (undergraduate and higher degree by research), increased funding for university mathematics and statistics, establishment of participation targets for Year 12 advanced mathematics and collaborative delivery models.

School student rural and regional participation (2009)

The Senate Rural and Regional Affairs and Transport References Committee conducted an inquiry to provide 'an assessment of the adequacy of Government measures to provide equitable access to secondary and post-secondary education opportunities for students from rural and regional communities' (2009, p. 5). The *Rural and Regional Access to Secondary and Tertiary Education Opportunities* report (Rural and Regional Affairs and Transport References Committee, 2009[158]) stated that, with respect to school-level education, 'the Committee is concerned at what it sees is a growing disparity in educational opportunities between rural and regional, and metropolitan areas' (p. 38), and subsequently recommended the development of strategies to address these inequities. With respect to higher education, the inquiry received evidence regarding inequities arising from financial barriers involved in participation in higher education (for example, moving from a rural or remote location to study; and issues associated with inadequate income support). The inquiry also heard evidence regarding social and community costs associated with young people's relocation away from home to pursue higher education opportunities. The report recommended the introduction of financial assistance programs to support rural and remote students transition to higher education and participate in workplacements; and funding for regional universities.

157 Australian Mathematical Sciences Institute 2012, *Maths for the Future: Keep Australia Competitive* (brochure), AMSI, Melbourne.

158 Senate Standing Committee on Rural & Regional Affairs & Transport 2009, *Rural and Regional access to Secondary and Tertiary Education Opportunities*, Australian Government, Canberra.

Mathematics, Engineering and Science in the National Interest (2012)

The *Mathematics, Engineering and Science in the National Interest* report released by the Office of the Chief Scientist in May, 2012 recommended a number of strategies aimed at enhancing school level mathematics and science:

> we need to ensure that the school sector maximises interest and provides opportunities for all students to study high quality mathematics and science leading to careers in those disciplines and in engineering (p. 6).

Recommendations included: supporting the implementation of the standards developed by the Australian Institute for Teaching and School Leadership (AITSL), targeted funding for university initial science and mathematics teacher education, internships for science, engineering and mathematics undergraduates, and support for mathematics and science teachers.

Subsequently, the Commonwealth government announced a $54 million funding commitment to mathematics, engineering and science[159] including $10.9 million for teacher training, $3 million for advice for teachers, $5 million for Science Connections, $20 million for the Australian Mathematics and Science Partnerships Program, $2 million for the Australian Mathematics Sciences Institute, $6.5 million for Science Partnerships, which supports the Scientists and Mathematicians in Schools project, $2.4 million for the Science and Mathematics Olympiads and $4.3 million for the National Mathematics and Science Education and Industry Adviser. In addition to supporting STEM-specific initiatives, this support should go some way to enhancing the profile of the STEM agenda.

Table 18: Projects funded by DEEWR to support Science and Mathematics education

Program and description
Scientists and Mathematicians in Schools program (2012–2016)
The aim of this project is to increase student interest and motivation in science and mathematics through exposure to the breadth of real world science and mathematics. To this end, the program links practising scientists and mathematicians with classroom teachers and their students. CSIRO manage the program.
Science Connections (2012–2016)
The aim of this project is to deliver high quality student and teacher resources aligned to the *Australian Curriculum: Science*, as well as professional learning to help teachers confidently teach science in their classrooms. This project, expected to be undertaken by the Australian Academy of Science, builds on the very successful *Primary Connections: Linking Science with Literacy* and *Science by Doing* initiatives.
Advice for Teachers of Science and School Laboratory Technicians (2012–2016)
The aim of this project is to provide advice and support for teachers of science and school laboratory technicians to ensure excellent teaching and stimulating, safe classroom activities (particularly, practical laboratory activities). The Australian Science Teachers Association has been funded to undertake this project.
Advice for Teachers of Mathematics (2012–2016)
The ‘Online Advice and Support for Teachers of Mathematics’ Project aims to provide Australian teachers of mathematics at all levels with access to a range of online networks and activities that support quality teaching of mathematics in the context of schools’ implementation of the *Australian Curriculum: Mathematics.* The Australian Association of Mathematics Teachers has been funded to undertake this project.
Mathematics and Science Illustrations of Practice (2012–2016)
The aim of this project is to develop and make available online videos which illustrate the National Professional Standards for Teachers in mathematics and science classrooms, including science laboratories – thereby raising the standard of teaching and, consequently, student engagement in mathematics and science education. The Australian Institute for Teaching and School Leadership is developing the first group of videos in 2012-13.
Science and Mathematics Olympiads (2013–2016)

[159] Chubb, I 2012, *$54 Million Commitment to Mathematics, Engineering and Science* (press release), Australian Government, Canberra, viewed 6 January 2013, http://www.chiefscientist.gov.au/2012/05/54-million-committment-to-mathematics-engineering-and-science-2/.

The Science and Mathematics Olympiads support the participation of Australia's most talented science and mathematics students in the annual International Science and Mathematics Olympiads. The Science Olympiads cover physics, chemistry and biology. The Mathematics Olympiad covers mathematics and informatics. The Australian Science Innovations and Australian Mathematics Trust are funded to manage Australia's involvement in the five Olympiad competitions and associated preliminary activities.

Source: DEEWR, unpublished

In December 2012, the Minister for Tertiary Education, Skills, Science and Research announced a call for projects under the Australian Maths and Science Partnerships Program (AMSPP) (Evans, 2012[160]). The objective of the AMSPP is to improve student engagement in mathematics and science courses at schools and university through innovative partnerships between universities, schools, and other relevant organisations. In 2013, the first round of grants will provide $5.3 million to fund nation-wide priority projects. Further competitive grants rounds will be available in 2014, 2015 and 2016 to support local mathematics and science activities.

Health of Australian Science (2012)

The *Health of Australian Science* report (2012) provided an overview of Australian science in terms of science-related education, research and development, teaching, the workforce and international collaboration. *Health of Australian Science* draws on the findings of commissioned research published in *Unhealthy Science? University Natural and Physical Sciences 2002-2009/10* by Dr Ian Dobson, *The Status and Quality of Year 11 and 12 Science in Australian Schools* by the Australian Academy of Science and *STEM and Non-STEM First Year Students* by Universities Australia. The report found that whilst overall 'Australian science is generally in good health' (p. x), there is a need to address concerns regarding participation and performance in school science, science literacy, participation in university science programs and funding for science research.

Table 19: Summary of schooling and teaching quality policies, reports and strategies

SCHOOLING AND TEACHING QUALITY POLICIES AND REPORTS	KEY POINTS RELEVANT TO STEM
Melbourne Declaration on Educational Goals for Young Australians (MCEETYA, 2008)	- Australian schools to develop knowledge in mathematics, science (physics, chemistry and biology) - literacy and numeracy, mathematics and English as foundation skills
Measurement Framework for Schooling in Australia (MCEECDYA, 2010)	- includes National Assessment Program (established earlier), including National Assessment Program – Literacy and Numeracy (NAPLAN), National Assessment Program – Science Literacy (NAP-SL) and National Assessment Program – ICT Literacy (NAP-ICT)
Australia's Teachers: Australia's Future: Advancing Innovation, Science, Technology and Mathematics (DEST, 2003)	- recruitment and retention of teachers of science, technology and mathematics - teacher professional development - school leadership
National Partnership Agreement on Improving Teacher Quality (COAG, 2008)	- attract, train, place, develop and retain quality teachers and school leaders - professional development - school principals - national accreditation of initial teacher education courses (against AITSL Graduate Standards) - national consistency in graduate teacher registration (against AITSL Proficient Standards) - performance management systems - professional development for teachers, principals and school leaders - data collection - teachers in rural and remote areas and disadvantaged Indigenous schools
Australian Professional Standards for Teachers (AITSL)	- standards for teaching quality

[160] Evans, C 2012, *New program to boost maths and science graduates* (press release), viewed 12 March 2013, http://minister.innovation.gov.au/chrisevans/MediaReleases/Pages/Newprogramtoboostmathsandsciencegraduates.aspx

Review of Funding for Schooling: Final Report (Gonski Report, 2011)	- significant injection of funding into the school system (majority to government sector to redress persistent disadvantages) - schooling resource standard to fund primary and secondary school students from all sectors, with loadings for disadvantaged students (SES, Indigenous, school size, location) - Schools Resourcing Body
National Plan for School Improvement (Australian government, 2012)	- Quality teaching with a focus on higher standards for teachers, improved teacher training, mentoring of new teachers, annual performance reviews against national teacher standards, as well as a focus on entry requirements for the teaching profession to ensure entrants are in the top 30 per cent of literacy and numeracy results, and a focus on training teachers to manage disruptive behaviour and bullying. - Quality learning would for example, require all schools to implement the Australian Curriculum ensuring every student will study and be assessed against the same curriculum, a greater focus on safe school environment and individual support for students. - More help for students who need it with funding available for students who need additional support – students from low SES communities, Indigenous students, students with disability, and students with limited English language proficiency as well as additional funding for rural and remote schools and for small schools in recognition of the extra costs associated in running these schools. - Empowering School Leadership providing autonomy for school principals to manage the hiring of staff and greater control over school budgets – so they can implement local solutions that benefit the children in their schools. - This would include School Improvement Plans for every school which outlines the steps each school will take to improve student results, and strengthen community and parent partnerships. - Transparency and Accountability with access to more detailed information for parents and the community, via the My School website, so they can see how their child or schools in their area are progressing. For example, information on specialist teachers, Year 12 attainment results, and the result of school surveys.
Great Teaching, Inspired Learning: Discussion Paper (NSW government, 2012)	- higher entry requirements into initial teaching programs
Science Engagement and Education: Equipping young Australians to lead us to the future (PMSEIC, 2003)	- goal: science-literate society through engagement of young Australians in science from school and careers (science literacy *and* basic literacy and numeracy) - science outreach programs - delivery of primary-school level science through literacy education - integration of science investigation pedagogies at junior secondary level - industry / education partnership - teaching quality
Victorian government inquiry into mathematics and science (Parliament of Victoria, 2006)	- professional development for primary school teachers (confidence and capacity in delivering mathematics and science) - professional development for secondary school teachers (content expertise, contemporary science, student engagement) - contemporary science equipment - careers and subject selection - teacher supply and demand
Maths for the Future: Keep Australia Competitive (AMSI, 2012)	- awareness raising - mathematics prerequisites for engineering degrees - mathematics preparation for school mathematics teachers and primary school teachers - university scholarships (undergraduate and higher degree by research) - funding for university mathematics and statistics - participation targets Year 12 advanced mathematics - collaborative delivery models
School student rural and regional participation (Australian government, 2009)	- financial assistance programs for rural and remote students transitioning to higher education and participating in workplacements - funding for regional universities
Mathematics, Engineering and Science in the National Interest (OCS, 2012)	- implementation of AITSL standards - university initial science and mathematics teacher education - internships for science, engineering and mathematics undergraduates - mathematics and science teachers
Health of Australian Science (OCS, 2012)	- participation and performance in school science - science literacy - participation in university science programs - funding for science research

LANGUAGE, LITERACY, NUMERACY AND GENERIC SKILLS

National Partnership Agreement on Literacy and Numeracy

The *National Partnership Agreement on Literacy and Numeracy* (LNNP) is an agreement between the Commonwealth, state and territory governments and school education sectors, under the *Intergovernmental Agreement on Federal Financial Relations* (IGA FFR). The *National Partnership Agreement on Literacy and Numeracy* aimed to support initiatives in approximately 10 percent of Australian schools to increase literacy and numeracy achievement, particularly for students from low SES and Indigenous backgrounds. Supported initiatives targeted school leadership, teaching quality and the use of performance data.

In evaluating the national partnership, the Australian National Audit Office reported in the review of the *National Partnership Agreement on Literacy and Numeracy* (Australian National Audit Office, 2012[161]) that:

> For schools participating in the LNNP, education authorities and schools have reported positive impacts of the LNNP on school leadership, teacher practice and student engagement. However, ANAO analysis of NAPLAN data from 2008 to 2011 indicates that the LNNP is yet to make a statistically significant improvement, in any state, on the average NAPLAN results of schools that received LNNP funding, when compared to schools that did not receive funding (2012, p. 100).

The Australian National Audit Office review revealed a large percentage of Indigenous students at or below the national minimum standards for reading and numeracy achievement. In 2011, the percentage increased as students progressed through Years 3-9, with 60.9 per cent of Year 9 Indigenous students in 2011 at or below the national minimum standard for reading and numeracy achievement, compared to 22.2 per cent of non-Indigenous Year 9 students. The review also revealed the persistent gap in achievement from 2008 to 2011, with only some minor narrowing of the gap (other than for Year 9 students).

Table 20: Numeracy: Change in the gap in achievement of Indigenous and non-Indigenous students, 2008-2011

YEAR LEVEL	2008			2011			CHANGE IN THE GAP (% POINTS)
	PERCENT OF INDIGENOUS STUDENTS AT OR BELOW THE NMS	PERCENT OF NON-INDIGENOUS AT OR BELOW NMS	GAP (% POINTS)	PERCENT OF INDIGENOUS STUDENTS AT OR BELOW THE NMS	PERCENT OF NON-INDIGENOUS AT OR BELOW NMS	GAP (% POINTS)	
3	46.9%	12.3%	34.6	43.3%	12.3%	31.0	-3.6
5	60.6%	21.2%	39.4	52.8%	15.6%	37.2	-2.2
7	53.5%	16.1%	37.4	53.1%	16.4%	36.7	-0.7
9	60.1%	21.4%	38.7	60.9%	22.2%	38.7	0.0

Source: Reproduced from ANAO analysis of ACARA, *National Assessment Program Literacy and Numeracy: National Report for 2011*, 2012 (ANAO, 2012, p. 99).

[161] Australian National Audit Office 2012, *Audit Report No.41 2011–12 Performance Audit National Partnerships Agreement on Literacy and Numeracy*, Australian Government, Canberra, viewed 5 January 2013, http://www.anao.gov.au/~/media/Uploads/Audit%20Reports/2011%2012/201112%20Audit%20Report%20No41.pdf.

National Foundation Skills Strategy for Adults (2012)

The COAG Standing Council on Tertiary Education Skills & Employment (SCOTESE) *National Foundation Skills Strategy for Adults* (2012)[162] has recognised the serious challenges associated with raising the foundation skills[163] of English language, literacy and numeracy (LLN) and employability skills for adults. These foundation skills are enablers for scientific literacy and high level STEM qualifications:

> Improving language, literacy and numeracy levels will also contribute to the realisation of targets to increase the qualification levels of Australians since literacy is fundamental to the ability to accumulate higher-level skills. Level 3 or higher language, literacy and numeracy (using the ALLS scale) is the level generally regarded as necessary for successful completion of a Certificate III or higher qualification. This highlights the need to lift the core skills of those at lower levels to provide more Australians with the foundation for the higher level skills essential for increased participation and economic productivity
> (Australian Workforce and Productivity Agency, 2010, p. 37[164]).

As noted previously, the COAG *National Foundation Skills Strategy for Adults* (2012) reported that '44 per cent of Australia's working age population (around 6 million people) have literacy levels below … the level needed to meet the complex demands of work and life in modern economies. This equates to 40 per cent of employed Australians, 60 per cent of unemployed Australians and 70 per cent of those outside the labour force. … (which) lend(s) weight to concerns about our ability to meet projected skills demands in coming years' (SCOTESE, 2012, p. 2 derived from the *Adult Literacy and Life Skills Survey, Summary Results,* Australian Bureau of Statistics, 2006)[165]. Despite concerted efforts to enhance language, literacy and numeracy skills the results of the 2006 Adult Literacy and Life Skills Survey reported little improvement from the International Adult Literacy Survey (IALS) conducted in 1996 (Skills Australia, 2010, p. 36). An aspirational target has been established, that 'by 2022, two thirds of working age Australians will have literacy and numeracy skills at Level 3 or above' (DIIRSTE, 2012[166]).

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162 Standing Committee on Tertiary Education Skills & Employment 2012, *National Foundation Skills Strategy for Adults*, Australian Government, Canberra, viewed 23 December 2012, http://www.innovation.gov.au/Skills/About/Policy/NationalFoundationSkillsStrategyForAdults/Pages/default.aspx.

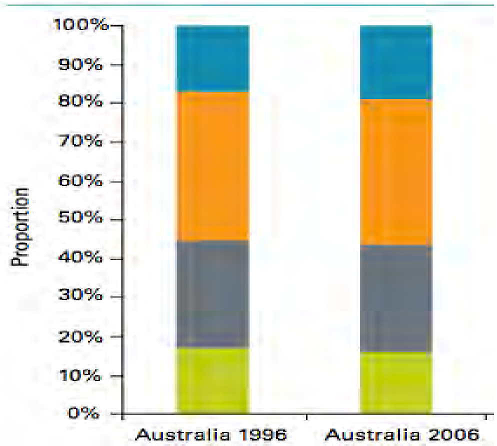
163 The National Foundation Skills Strategy for Adults (2012) defines foundation skills as 'English language, literacy and numeracy (LLN) – listening, speaking, reading, writing, digital literacy and use of mathematical ideas; and employability skills, such as collaboration, problem solving, self-management, learning and information and communication technology (ICT) skills required for participation in modern workplaces and contemporary life' (p. 2).

164 Australian Workforce and Productivity Agency 2010, *Australian Workforce Futures A National Workforce Development Strategy,* Australian Government, Canberra.

165 Australian Bureau of Statistics 2006, *4228.0 - Adult Literacy and Life Skills Survey, Summary Results, Australia, 2006 (Reissue)*, Australian Government, Canberra.

166 Department of Industry, Innovation, Science, Research and Tertiary Education 2012, *National Foundation Skills Strategy for Adults* (webpage), viewed 13 January 2013, http://www.innovation.gov.au/Skills/About/Policy/NationalFoundationSkillsStrategyForAdults/Pages/default.aspx.

Figure 23: Change in adult reading literacy 1996-2006 (IALS, ALLS)



Source: Skills Australia 2010, *Australian Workforce Futures*, p. 36.

Table 21: Summary of language, literacy, numeracy and generic skills policies, reports and strategies

LANGUAGE, LITERACY, NUMERACY AND GENERIC SKILLS POLICIES AND REPORTS	KEY POINTS RELEVANT TO STEM
National Partnership Agreement on Literacy and Numeracy	- literacy and numeracy, particularly for students from low SES and Indigenous backgrounds - school leadership - teaching quality - performance data
National Foundation Skills Strategy for Adults (COAG, 2012)	- language, literacy and numeracy skills - employability skills for adults

UNIVERSITIES, RESEARCH & DEVELOPMENT (R&D), INNOVATION

Bradley Review

The Commonwealth government commissioned the Review of Higher Education to examine the Australian higher education sector. The *Review of Higher Education Final Report* (2008[167]) (the Bradley review) found that Australia's performance and investment in higher education was falling from an international comparative perspective. The report stated that:

> The nation will need more well-qualified people if it is to anticipate and meet the demands of a rapidly moving global economy. Work by Access Economics predicts that from 2010 the supply of people with undergraduate qualifications will not keep up with demand. To increase the numbers participating we must also look to members of groups currently under-represented within the system, that is, those disadvantaged by the circumstances of their birth: Indigenous people, people with low socio-economic status, and those from regional and remote areas. (2008, p. xv)

[167] Bradley et al. 2008, *Review of Higher Education Final Report*, Australian Government, Canberra, viewed 12 January 2013, http://www.innovation.gov.au/HigherEducation/Documents/Review/PDF/Higher%20Education%20Review_one%20document_02.pdf.

The *Review of Higher Education Final Report* identifies key policy interventions over the last 20 years as:

- increasing the percentage of the population participating in higher education;
- increasing the diversity of university income sources, including from international students;
- increasing the contribution by students to the costs of their education;
- improving productivity and efficiency in higher education;
- introducing competitive or performance-based funding; and
- diversifying higher education by government support for private provision (p. 4).

The review recommended establishing a national target for the attainment of bachelor level qualifications (or higher), of at least 40 per cent of 25-34 year olds by 2020. The *Review of Higher Education Final Report* recommended substantially increasing participation in the Australian higher education system, particularly for people from low SES backgrounds. In terms of performance monitoring regimes, the Bradley review recommended that universities implement the Graduate Destination Survey, Course Experience Questionnaire and Australasian Survey of Student Engagement. In addition, the review recommended the introduction of a new higher education sector regulator.

The government's response, *Transforming Australia's Higher Education System* (2010) included commitments to uncap university places, resulting in demand driven funding. The response also committed the Commonwealth to 'high quality teaching and learning, improve access and outcomes for students from low socio economic backgrounds, build new links between universities and disadvantaged schools, reward institutions for meeting agreed quality and equity outcomes, improve resourcing for research and invest in world class tertiary education infrastructure' (DIISRTE, 2012[168]).

In 2012, the government introduced a demand driven funding system for bachelor degree places, where universities are funded for every domestic bachelor degree student they enrol in eligible courses. This system aims to increase the number of graduates and provide universities flexibility to respond to changing student and employer demand. The *MyUniversity* website was released in April 2012 to assist students to make informed choices regarding university courses and student services. The *Undergraduate Applications, Offers and Acceptances 2012* data indicate that the largest growth in university offers is in health, engineering and natural and physical sciences (DEEWR, 2012[169]).

The government also established the Tertiary Education Quality Standards Agency (TEQSA) as the sector regulator under the *Tertiary Education Quality and Standards Agency Act 2011.* TEQSA will accredit and monitor higher education providers under a legislative instrument, the *Higher Education Standards Framework (Threshold Standards*[170]).

Cutler Review

168 Department of Industry, Innovation, Science, Research and Tertiary Education 2012, *Review of Australian Higher Education* (webpage), viewed 12 January 2013, http://www.innovation.gov.au/HigherEducation/ResourcesAndPublications/ReviewOfAustralianHigherEducation/Pages/default.aspx.

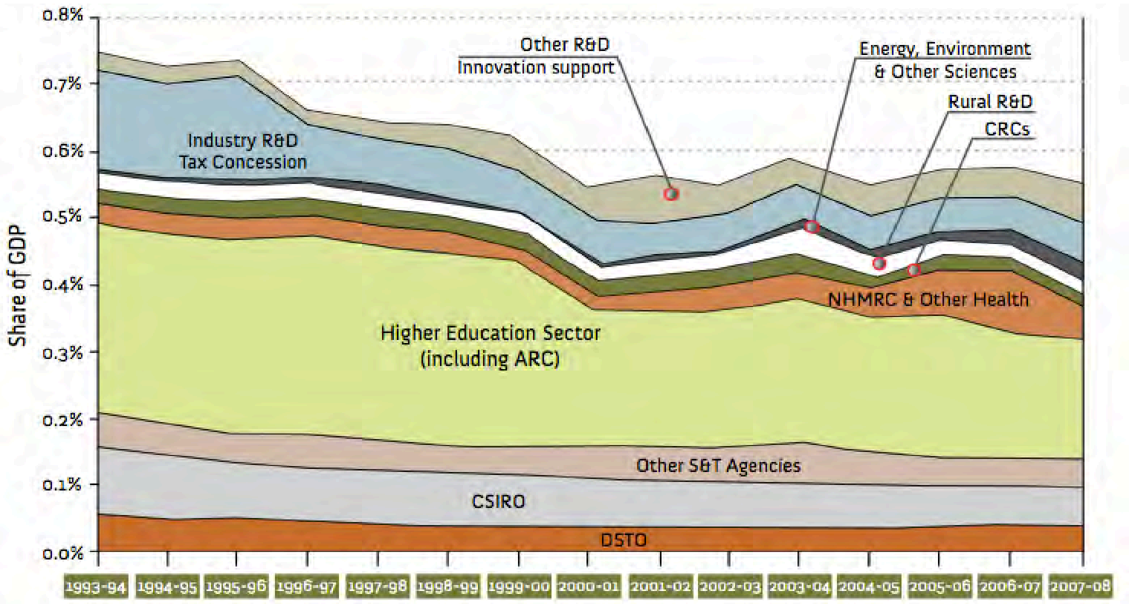
169 Department of Industry, Innovation, Science, Research and Tertiary Education 2012, *Undergraduate Applications Offers and Acceptances Reports*, viewed 12 March 2013, http://www.innovation.gov.au/HigherEducation/ResourcesAndPublications/HigherEducationPublications/HigherEducationReports/Pages/UndergraduateApplicationsOffersAndAcceptancesReports.aspx.

170 Australian Government 2012, *Higher Education Standards Framework (Threshold Standards)*, Australian Government, Canberra, viewed 13 January 2013, http://www.comlaw.gov.au/Details/F2012L00003/Download.

The government commissioned a review of Australia's innovation system. *Venturous Australia - building strength in innovation* (Cutler & Company, 2008) found that:

> the rate of improvement (in innovation) has stalled over the last decade and some indicators suggest absolute decline. Furthermore, much of it appears to have been a response to our own policy decisions. … as a share of Gross Domestic Product (GDP), Australian Government support for science and innovation, has fallen by nearly a quarter. Also the number of researchers per thousand employees has declined substantially in the last decade, and US patents granted per 1,000 population have plunged from 0.06 to 0.01 (1999–2003). (p. 2)

Figure 24: Australian government expenditure on science and innovation 1993-94 to 2007-08, as a proportion of GDP



Source: Cutler & Company 2008, *Venturous Australia – building strength in innovation*, p. 2.

With respect to government policy responses to innovation, the review found 'a lack of policy coherence reflected in a fragmentation of innovation resources across government and between state, territory and federal governments' (*ibid*., p. 11). *Venturous Australia - building strength in innovation* recommended building innovative businesses, investing in human capital, enhancing research capability and platforms (including full funding for the costs of university research) and tax incentive reform. In terms of human capital specifically, the review recommended support for 'the human capital focus of the COAG national reform agenda; the broader national education reforms, and their central focus on raising teaching quality; innovation being considered as a key element of these and future substantial national reforms' (*ibid.,* p. 16). The report also proposed national public sector innovation priorities (agricultural and food security, climate change mitigation and adaptation, population health, solutions in tropical environments, and applications to utilise broadband infrastructure) and private sector innovation priorities (resource industries, space and astronomy, finance and risk management, and marine industries) (*ibid.,* pp. 10-11).

The government's response, *Powering Ideas: An Innovation Agenda for the 21st Century* (2009) established the following national innovation priorities:

> Priority 1: Public research funding supports high-quality research that addresses national challenges and opens up new opportunities.
> Priority 2: Australia has a strong base of skilled researchers to support the national research effort in both the public and private sectors.
> Priority 3: The innovation system fosters industries of the future, securing value from the commercialisation of Australian research and development.
> Priority 4: More effective dissemination of new technologies, processes, and ideas increases innovation across the economy, with a particular focus on small and medium-sized enterprises.
> Priority 5: The innovation system encourages a culture of collaboration within the research sector and between researchers and industry.
> Priority 6: Australian researchers and businesses are involved in more international collaborations on research and development.
> Priority 7: The public and community sectors work with others in the innovation system to improve policy development and service delivery (p. 4).

The government committed to increasing research group performance, introducing mission-based compacts, progressively increasing funding for indirect research costs, establishing a Collaborative Research Networks Scheme, supporting research infrastructure and increasing higher degrees by research students numbers (Australian Government, 2009[171]).

Base Funding Review

The government commissioned the Review of Higher Education Funding (the Lomax-Smith review) to examine university funding arrangements. The report, *Higher Education Base Funding Review: Final Report* (2011[172]), found that:

> The diverse system includes areas of research excellence, high-quality and innovative teaching, and a widespread focus on equity. Our national system is well regarded at home, respected internationally and a source of national pride. Nevertheless, specific local issues, changing policy settings and rapid global changes have the potential to pose significant risks to the quality and effectiveness of Australian universities (p. vii).

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[171] Australian Government 2009, *Future Directions for Higher Education — the Government's response to the Reviews of Australian Higher Education and National Innovation System* (webpage), viewed 13 January 2013, http://www.budget.gov.au/2009-10/content/ministerial_statements/deewr/html/ms_deewr-05.htm.

[172] Lomax-Smith et al. 2011, *Higher Education Base Funding Review Final Report*, Australian Government, Canberra, viewed 13 January 2013, http://www.innovation.gov.au/HigherEducation/Policy/BaseFundingReview/Documents/HigherEd_FundingReviewReport.pdf.

The report summarised the current funding arrangements, as follows:

Table 22: CGS funding clusters and maximum student contributions for an equivalent full-time student load, 2011

Funding cluster	Part of funding cluster	Maximum student contribution amounts	Australian Government contribution ($)	Total resourcing ($)	Weighting
Funding cluster 1 Law, accounting, commerce, economics, administration		9,080	1,793	10,873	1.0
Funding cluster 2 Humanities		5,442	4,979	10,421	1.0
Funding cluster 3 Mathematics, statistics, behavioural science, social studies, computing, built environment, other health	Mathematics, statistics	4,355	12,179[a]	16,534	1.6
	Computing, built environment or other health	7,756	8,808	16,564	
	Behavioural science or social studies	5,442		14,250	1.4
Funding cluster 4 Education		5,442	9,164	14,606	1.4
Funding cluster 5 Clinical psychology, allied health, foreign languages, visual and performing arts	Clinical psychology, foreign languages, or visual and performing arts	5,442	10,832	16,274	1.6
	Allied health	7,756		18,588	1.8
Funding cluster 6 Nursing		5,442	12,093	17,535	1.7
Funding cluster 7 Engineering, science, surveying	Science	4,355	18,769[a]	23,124	2.2
	Engineering or surveying	7,756	15,398	23,154	
Funding cluster 8 Dentistry, medicine, veterinary science, agriculture	Dentistry, medicine or veterinary science	9,080	19,542	28,622	2.8
	Agriculture	7,756		27,298	2.6

Source: Lomax-Smith et al. 2011, *Higher Education Base Funding Review: Final Report*, p. 6.

The review found that the current funding arrangements no longer reflect costs for teaching, scholarship, and a base level of research, with several groups of disciplines, in particular, underfunded (that is, accounting, administration, economics, commerce; and medicine, dentistry, agriculture, veterinary science, and visual and performing arts).

With respect to differentiated funding arrangements for disciplines aligned with actual or projected labour market shortages – such as the HECS-HELP benefit for mathematics, science, education and nursing graduates that reduces the graduate's accumulated HELP debt[173] - the report stated that the panel 'found no compelling evidence that lowering student contributions for the purpose of increasing enrolments in areas of skills shortages has any significant impact' (*ibid*., p. xiv).

The *Higher Education Base Funding Review: Final Report* recommended that the average level of base funding be increased, measures be introduced to address funding for disciplines currently underfunded, and a consistent contribution mix be introduced (that is, 40 per cent students, 60 per cent government) for government supported places.

173 Eligible mathematics or science graduates, who take up employment in related occupations, are able to apply for the HECS-HELP benefit to reduce their compulsory HELP debt repayments. Related occupations include the teaching of these subjects in secondary school and primary school teaching. Refer to Australian Taxation Office 2012, *HECS-HELP benefit for maths, science, education and nursing (including midwifery) graduates*, viewed 5 March 2013, http://www.ato.gov.au/individuals/content.aspx?menuid=0&doc=/content/00247378.htm&page=4&H4.

The government's response states that 'the Review made 24 principal recommendations with another 5 recommendations concerning implementation. The Government has accepted, either in full or in part, 13 of the 24 principal recommendations' (DIISRTE, 2013, n.p.[174]). However, sector observers see the government response as a comprehensive rejection of the fundamental review outcomes and recommendations (refer Hare, 2013[175]). For example, Universities Australia stated that 'The Federal Government's response to Dr Jane Lomax-Smith's Base Funding Review Report is a disappointing dismissal of the findings of a Report that it commissioned which found that public investment in universities is under done. … Today's response disappointingly includes no commitment to increase investment in universities. This is despite the review's finding that increased funding is needed 'to maximise the sector's potential to contribute to national productivity and economic growth' (Robinson, 2013[176]).

Table 23: Summary of university, research and development and innovation policies, reports and strategies

UNIVERSITY, R&D, INNOVATION POLICIES AND REPORTS	KEY POINTS RELEVANT TO STEM
Review of Higher Education Final Report (Bradley review, 2008)	- increase participation in higher education, particularly for low SES - performance monitoring systems (Graduate Destination Survey, Course Experience Questionnaire and Australasian Survey of Student Engagement) - higher education sector regulator
Transforming Australia's Higher Education System (Australian Government, 2010)	- uncapped university places - teaching quality - access and outcomes for low SES - linkages disadvantaged schools and universities - research - infrastructure - Tertiary Education Quality Standards Agency (TEQSA)
Venturous Australia – building strength in innovation (Cutler review, 2008)	- innovative businesses - human capital - research capability and platforms - tax incentive reform - national innovation priorities
Powering Ideas: An Innovation Agenda for the 21st Century (Australian Government, 2009)	- research group performance - mission-based compacts - funding for indirect research costs - Collaborative Research Networks Scheme - research infrastructure - higher degree by research students
Higher Education Base Funding Review: Final Report (Lomax-Smith review, 2011)	- increase average level of base funding - support underfunded disciplines - consistent student : government contribution mix (40% / 60%)

LABOUR MARKET

Skills Australia - Australian Workforce Futures (2010)

The Commonwealth government established Skills Australia under the *Skilling Australia for the Future Policy* (2008) as an independent statutory body to advise the Minister for Tertiary Education, Skills, Science and Research on future skill and development requirements. The Skills Australia report, *Australian Workforce Futures* (2010), examined scenarios for future workforce and qualifications capability requirements, recommended a labour market planning framework encompassing Skills Australia, Commonwealth and state and territory government and industry, and recommended 'skills deepening' (p. 8) and higher education, training and workforce participation. The *Australian Workforce Futures* identified 'looming workforce replacement issues for the tertiary education sector

174 DIISRTE 2013, *Government Response to the Higher Education Base Funding Review Final Report*, viewed 4 March 2013, http://www.innovation.gov.au/HigherEducation/Policy/BaseFundingReview/Pages/ResponseToBaseFundingReview.aspx.

175 Hare, J 2013, *Government shelves uni teaching report,* The Australian, 29 January 2013, viewed 4 March 2013, http://www.theaustralian.com.au/higher-education/government-shelves-uni-teaching-report/story-e6frgcjx-1226563782933.

176 Robinson, R 2013, *Disappointing Base Funding Review response a squandered opportunity : UA*, 28 January 2013, viewed 4 March 2013, http://the-scan.com/2013/01/28/disappointing-base-funding-review-response-a-squandered-opportunity-ua/

which, like several other industries, has an ageing workforce requiring a major initiative in workforce development' (*op cit*., p. 6), and recommended a significant injection of funding to address this. The report suggests that skills gaps could be addressed through a combination of strategies focusing on: 'enrolments—provision of extra places and incentives to attract more students; the composition of the migration intake—more skilled people rather than increased migration …; raising educational completion rates' (*op. cit.,* p. 17).

National Resources Sector Employment Taskforce final report: Resourcing the future (2011)

In 2009 the Commonwealth government established the National Resources Sector Employment Taskforce 'to help secure the skilled workforce required to build and operate major resources sector projects over the next five years' (The Hon Gary Gray MP, in the covering letter to the final report, p. ii).

The taskforce report, *Resourcing the future National Resources Sector Employment Taskforce Report* (2010[177]), stated that the solution may lie in both strengthened education institutional outcomes for all (including schools, vocational education and universities), and the targeted recruitment of groups currently under-represented in the resources sector including Indigenous Australians and women:

> The right approach to the (resources) sector's skill needs must be demand driven and include improving our schools, developing our apprenticeship system, strengthening our universities and creating a more efficient labour market. It can also help address the unemployment and social disadvantage that persist in some segments of the community, most notably among Indigenous Australians. Effective strategies could also go some way towards addressing the average income differences between male and female workers and between metropolitan and regional areas. (p. 2)

Resourcing the future revealed emerging shortages for mining engineers and geoscientists (estimated at 1,700 and 3,000 respectively), whilst noting that people currently holding these qualifications were working outside the resources sector (p. 3). The report provided a number of recommendations concerning workforce planning and development, trade professionals, university qualified engineers and geoscientists (including internships and mentoring arrangements), temporary migration solutions, and language, literacy and numeracy proficiency development of potential workforce participants. The Minister for Tertiary Education, Skills, Jobs and Workplace Relations accepted the recommendations in March, 2011.

Skills Australia - Engineering Pathways Seminar (2011)

Following the release of *Pathways from VET awards to engineering degrees: a higher education perspective* (King, Dowling and Godfrey, 2011[178]) commissioned by the Australian Council of Engineering Deans, Skills Australia convened an Engineering Pathways Seminar (December, 2011). The objective of the seminar was to examine the role of vocational education and training qualifications (Diplomas and Advanced Diplomas at Australian Qualification Framework levels V and VI respectively) in

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177 National Resources Sector Employment Taskforce 2010, *Resourcing the future National Resources Sector Employment Taskforce Report*, Australian government, viewed 4 March 2013, http://www.innovation.gov.au/Skills/National/Documents/FinalReport.pdf.

178 King, R, Dowling, D & Godfrey, E 2011, *Pathways from VET awards to engineering degrees: a higher education perspective*, Australian Council of Engineering Deans, viewed 28 December 2012, http://www.anet.org.au/wp-content/uploads/2011/06/ANET-Higher-Ed-pathways.pdf.

potentially addressing engineering skills shortages. Participants noted the difference between trade (AQF levels III/IV), paraprofessional (AQF V/VI) and professional (AQF 7-10) engineering qualifications, and suggested that students undertaking AQF III/IV engineering trade qualifications may provide 'fertile ground for growing the engineering technicians and professionals of the future' (Skills Australia, 2011, p. 2). Participants also noted that articulation from lower AQF-level qualifications to AQF V/VI or higher education qualifications in engineering required foundation skills (primarily mathematics) and identified 'a need to strengthen maths and science at all levels' (*ibid.,* p. 5).

Australian Workforce and Productivity Agency - Australia's skills and workforce development needs (2012)

The Australian Workforce and Productivity Agency (AWPA) was subsequently established by the Commonwealth government to replace Skills Australia in July 2012, under the *Skills Australia Amendment (Australian Workforce and Productivity Agency) Bill* 2012[179]. The Agency is responsible for co-ordination between the government, industry and training providers with respect to workforce and qualifications needs. The Agency will conduct research regarding Australia's future workforce requirements and scope workforce development policy.

The AWPA Discussion Paper *Future focus: Australia's skills and workforce development needs* (2012[180]) examined the skills and workforce development needs arising from four proposed scenarios (that is, long boom, smart recovery, terms of trade shock, ring of fire). The Discussion Paper reported that 'skills shortages in some areas and industries threaten wage inflation and risk growth-constraining monetary tightening' (*ibid*., p. 1), and subsequently suggested that 'the demand for higher levels of skill is a reality … (and) this can be expected to continue into the future in response to technology-induced change, structural adjustment, a progressive shift to service-based industries, and Australia's changing demographics' (*ibid*., p. 1). The Discussion Paper invited contributions to the development of the Commonwealth government's *2012 National Workforce Development Strategy*.

Forecasting – labour market needs

The Commonwealth Department of Education, Employment and Workplace Relations (DEEWR) *Labour Market Information Portal*[181] provides national, state and regional information regarding the labour market. The Australian Workforce and Productivity Agency (AWPA) Labour Market Information section is 'developing a strong evidence base to understand and inform about the skill needs of our labour market, currently, and into the medium to longer term' (AWPA, 2012)[182].

Table 24: Summary of labour market policies, reports and strategies

LABOUR MARKET POLICIES AND REPORTS	KEY POINTS RELEVANT TO STEM
Australian Workforce Futures (Skills Australia, 2010)	- labour market planning framework - participation in tertiary education sector - skilled migration - education completion rates
Resourcing the future	- strengthened education (school, VET, university)

179 Parliament of Australia 2012, *Skills Australia Amendment (Australian Workforce and Productivity Agency) Bill,* viewed 30 December 2012, http://www.aph.gov.au/Parliamentary_Business/Bills_Legislation/Bills_Search_Results/Result?bId=r4757

180 Australian Workforce and Productivity Agency 2012, *Future focus: Australia's skills and workforce development needs*, viewed 30 December 2012, http://www.awpa.gov.au/publications/documents/Future-Focus-Australias-skills-and-workforce-development-needs-Discussion-Paper.pdf.

181 Department of Education, Employment and Workplace Relations 2012, *Labour Market Information Portal*, DEEWR, Canberra, viewed 30 December 2012, http://www.deewr.gov.au/lmip/.

182 Australian Workplace and Productivity Agency 2012, *Labour Market Information,* Australian Government, Canberra, viewed 30 December 2012, http://www.awpa.gov.au/our-work/labour-market-information/Pages/default.aspx.

(National Resources Sector Employment Taskforce, 2011)	- targeted recruitment of Indigenous Australians, women and people in remote areas to the resources sector - workforce planning and development - trade professionals - university qualified engineers and geoscientists (internships, mentoring) - temporary migration - language, literacy and numeracy development
Engineering Pathways Seminar (Skills Australia, 2011)	- strengthen mathematics at all levels

ENGAGING THE COMMUNITY

Science communications centres

The Australian National Centre for the Public Awareness of Science (CPAS) at the Australian National University (ANU) was established as Australia's first science communications centre in 1996. The Centre aims to 'empower Australians by encouraging in them a confident "ownership" of modern science, increasing science awareness in the community and improving the communication skills of scientists' (CPAS ANU webpage[183]). The Centre is seeking to identify strategies to engage people with science 'to encourage informed decisions about scientific issues that will concern us in the 21st century' (*ibid*.).

National strategy for community engagement with the sciences

The Commonwealth government's *Inspiring Australia: A national strategy for engagement with the sciences* (Department of Innovation Industry, Science and Research, 2011) was developed following evaluations of Australia's science engagement initiatives[184]. Evaluations included the PMSEIC Working Group on Science Engagement and Education *Science Engagement and Education* (2003), the Questacon *Audit of Science Education and Awareness Initiatives* (2007) and Questacon *Science Connections Program Evaluation Report* (2009). These evaluations suggested that science communications were fragmented, and recommended the need for a concerted, co-ordinated national strategy for community engagement with science.

The *Inspiring Australia* strategy established a framework for public engagement with broadly defined science to:

> increase appreciation of science in Australian culture, facilitate informed citizen participation in decision making and science policy development, boost confidence in the Australian Government's research investment, and ensure a continuing supply of well uqalified science graduates (DIISR, 2011, p. xv11).

The three year national program (2011-14) supported the Unlocking Australia's Potential Program to foster involvement in science, National Science Week, the Prime Minister's Prizes for Science, media-skills development projects, and Science and Society projects such as Science Meets Parliament.

183 Centre for the Public Awareness of Science 2012, *About CPAS* (webpage), Australian National University, Canberra, viewed 29 December 2012, http://cpas.anu.edu.au/about-cpas.

184 See, for example, PMSEIC Working Group on Science Engagement and Education 2003, *Science Engagement and Education,* PMSEIC, Canberra; Coordination Committee on Science and Technology, Science Education and Awareness Standing Group 2008, *Audit of Science Education and Awareness Initiatives* by Federal Government departments and agencies for the 2006– 07 financial year, Results and Recommendations, CCST, Canberra; DIISR *Review of Questacon — The National Science and Technology Centre*, 2008; Cutler review 2008, *Venturous Australia: Building Strength in Innovation*, Cutler & Company, Melbourne; Department of Innovation, Industry, Science and Research 2009, *Science Connections Program Evaluation Report* 2009, DIISR.

Table 25: Summary of community engagement policies, reports and strategies

COMMUNITY ENGAGEMENT POLICIES AND INITIATIVES	KEY POINTS RELEVANT TO STEM
Centre for Public Awareness of Science (ANU)	- community engagement with science - communication skills of scientists
Inspiring Australia: A national strategy for engagement with the sciences (DIISR, 2011)	- national strategy for community engagement with science - Unlocking Australia's Potential Program - National Science Week - Prime Minister's Prizes for Science - media-skills development projects - Science and Society projects

INDIGENOUS AUSTRALIANS

COAG National Indigenous Reform Agreement: Closing the Gap (2008)

The COAG *National Indigenous Reform Agreement* (2008) is an agreement between the Commonwealth and state and territory governments. The agreement established the following targets with respect to Indigenous health, education and employment outcomes:

(a) closing the life expectancy gap within a generation;
(b) halving the gap in mortality rates for Indigenous children under five within a decade;
(c) ensuring all Indigenous four years olds in remote communities have access to early childhood education within five years (by 2013*);
(d) halving the gap for Indigenous students in reading, writing and numeracy within a decade (by 2018*);
(e) halving the gap for Indigenous people aged 20-24 in Year 12 attainment or equivalent attainment rates by 2020; and
(f) halving the gap in employment outcomes between Indigenous and non-Indigenous Australians within a decade (by 2018*) (*dates added, p. 8[185]).

This agreement is supported by bilateral indigenous plans agreed between the Commonwealth and each individual state and territory. In terms of progress, the *Review of Funding for Schooling* reported that 'While early evidence suggests that these initiatives are having some success, progress is being made slowing and is not consistent across the states and territories. In their 2010 progress report, the COAG Reform Council (2011) indicated it may be difficult to meet targets set out in the National Education Agreement given some states and territories failed to meet their progress points in each domain and year' (Gonski et al., *op cit.* p. 115).

Australian Curriculum – Cross-Curriculum Priority for all students

The Australian Curriculum is being promoted as one strategy to recognise Indigenous culture and knowledge. One of the three cross-curriculum priorities applicable to curriculum for all students is Aboriginal and Torres Strait Islander histories and cultures. ACARA stated that 'the Australian Curriculum also means that all young Australians can learn about the histories and cultures of Aboriginal and Torres Strait Islander peoples, of their contribution to Australia, and of the consequences of colonial settlement for Indigenous communities, past and present' (ACARA, 2012[186], p. 7). This cross-

[185] Council of Australian Governments 2008, *National Indigenous Reform Agreement Closing the Gap*, viewed 11 January 2013, http://www.federalfinancialrelations.gov.au/content/npa/health_indigenous/indigenous-reform/national-agreement_sept_12.pdf.

[186] Australian Curriculum, Assessment and Reporting Authority 2012, *The Shape of the Australian Curriculum*, ACARA, Sydney, viewed 11 January 2013, http://www.acara.edu.au/curriculum/curriculum_design_and_development.html.

curriculum priority includes the concepts of Country/Place, Peoples and Culture, and these concepts are embedded in the Australian Curriculum in all learning areas.

Figure 25: Organising ideas for Australian Curriculum cross-curriculum priority, Aboriginal and Torres Strait Islander histories and cultures

Code	Organising ideas
Country/Place	
OI.1	Australia has two distinct Indigenous groups, Aboriginal Peoples and Torres Strait Islander Peoples.
OI.2	Aboriginal and Torres Strait Islander communities maintain a special connection to and responsibility for Country/Place throughout all of Australia.
OI.3	Aboriginal and Torres Strait Islander Peoples have unique belief systems and are spiritually connected to the land, sea, sky and waterways.
Culture	
OI.4	Aboriginal and Torres Strait Islander societies have many Language Groups.
OI.5	Aboriginal and Torres Strait Islander Peoples' ways of life are uniquely expressed through ways of being, knowing, thinking and doing.
OI.6	Aboriginal and Torres Strait Islander Peoples have lived in Australia for tens of thousands of years and experiences can be viewed through historical, social and political lenses.
People	
OI.7	The broader Aboriginal and Torres Strait Islander societies encompass a diversity of nations across Australia.
OI.8	Aboriginal and Torres Strait Islander Peoples have sophisticated family and kinship structures.
OI.9	Australia acknowledges the significant contributions of Aboriginal and Torres Strait Islander people locally and globally.

Source: ACARA 2012, *Aboriginal and Torres Strait Islander histories and culture* (webpage)[187]

For example, through the F-10 Australian Curriculum: Mathematics:

> Students will explore connections between representations of number and pattern and how they relate to aspects of Aboriginal and Torres Strait Islander cultures. They will investigate time, place, relationships and measurement concepts in Aboriginal and Torres Strait Islander contexts. Students will deepen their understanding of the lives of Aboriginal and Torres Strait Islander Peoples through the application and evaluation of statistical data. (ACARA, 2012[188])

Similarly, through the F-10 Australian Curriculum: Science:

> Students will have opportunities to learn that Aboriginal and Torres Strait Islander Peoples have developed knowledge about the world through observation, using all the senses; through prediction and hypothesis; through testing (trial and error); and through making generalisations within specific contexts. These scientific methods have been practised and transmitted from one generation to the next. Students will develop an understanding that Aboriginal and Torres Strait Islander Peoples have particular ways of knowing the world and continue to be innovative in providing significant contributions to development in science. They will investigate examples of

[187] Australian Curriculum, Assessment and Reporting Authority 2012, *Aboriginal and Torres Strait Islander histories and cultures* (webpage), viewed 13 January 2013, http://www.australiancurriculum.edu.au/CrossCurriculumPriorities/Aboriginal-and-Torres-Strait-Islander-histories-and-cultures.

[188] Australian Curriculum, Assessment and Reporting 2012, *Cross-curriculum priorities* (webpage), viewed 13 January 2013, http://www.australiancurriculum.edu.au/Mathematics/Cross-Curriculum-Priorities#Aboriginal-and-Torres-Strait-Islander-histories-and-cultures.

Aboriginal and Torres Strait Islander science and the ways traditional knowledge and western scientific knowledge can be complementary. (ACARA, 2012[189])

Aboriginal and Torres Strait Islander Education Action Plan 2010-2014

The *Aboriginal and Torres Strait Islander Education Action Plan 2010-2014*, developed by the Ministerial Council for Education, Early Childhood Development and Youth Affairs (MCEECDYA[190]) (now the Standing Council on School Education and Early Childhood – SCSEEC), committed to closing the gap between Indigenous and non-Indigenous school students. The plan progressed the *National Aboriginal and Torres Strait Islander Education Policy* (DEEWR[191]) and built on various related agreements concerning health, early childhood, literacy and numeracy, housing, schooling and service delivery. The *Aboriginal and Torres Strait Islander Education Action Plan 2010-2014* supported initiatives focused on readiness for school, engagement, attendance, literacy and numeracy, leadership, quality teaching, workforce development and pathways to post-school options.

National Indigenous Higher Education Workforce Strategy (2011)

The *National Indigenous Higher Education Workforce Strategy* (2011[192]) was developed by the Indigenous Higher Education Advisory Council. The strategy built on recommendations of the House of Representatives Standing Committee on Industry, Science and Innovation's *Building Australia's Research Strategy* regarding Indigenous student participation in higher degrees by research.

The Indigenous Higher Education Advisory Council found that Indigenous academic staff are significantly under-represented in the academic labour force, to varying levels in each state and territory (for example, 0.3 per cent Indigenous academics in the Australian Capital Territory, compared with a population representation of 1.3 per cent; to 7.6 per cent in the Northern Territory, compared with a population representation of 29.6 per cent). South Australian universities, employing 0.9 per cent Indigenous academic staff, were closest to the population representation figure (1.3 per cent, for South Australia) (*ibid)*. The strategy established initiatives focused on employment pathways for existing Indigenous employees, new employment opportunities for Indigenous people, the working environment and community engagement and outreach (p. 5).

Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People

The Commonwealth government commissioned the *Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People* (2012) (the Behrendt review) to examine how higher education contributes to Indigenous wellbeing (in health, education and economic terms). The report:

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189 Australian Curriculum, Assessment and Reporting Authority 2012, *Cross-curriculum priorities* (webpage), viewed 13 January 2013, http://www.australiancurriculum.edu.au/Science/Cross-Curriculum-Priorities#Aboriginal-and-Torres-Strait-Islander-histories-and-cultures.

190 Ministerial Council for Education, Early Childhood Development And Youth Affairs, *Aboriginal and Torres Strait Islander Education Action Plan 2010-2014*, viewed 13 January 2013, http://www.mceecdya.edu.au/verve/_resources/a10-0945_ieap_web_version_final2.pdf.

191 Department of Education, Employment and Workplace Relations 2011, *National Indigenous Higher Education Workforce Strategy*, viewed 14 January 2013, http://deewr.gov.au/national-aboriginal-and-torres-strait-islander-education-policy

192 Indigenous Higher Education Advisory Council 2011, *National Indigenous Higher Education Workforce Strategy*, viewed 14 January 2013, http://www.innovation.gov.au/HigherEducation/IndigenousHigherEducation/IndigenousHigherEducationAdvisoryCouncil/Documents/IHEAC/NIHEWS.pdf.

- focuses on current approaches impacting participation and completion by Aboriginal and Torres Strait Islander students
- focuses on the role of Aboriginal and Torres Strait Islander staff in universities, particularly in academic and research roles
- recommends a lead role for the Indigenous Higher Education Advisory Council to lead the development of an Aboriginal and Torres Strait Islander Higher Education and Research Strategy and to progress the findings of the Review. (DIISRTE, 2012[193])

The review recommended strategies be developed to recognise Indigenous knowledge, support Indigenous student success, establish professional partnerships, support Indigenous higher degree by research students, researchers and existing university staff and reframe university governance.

The review highlighted that the current clustering of Aboriginal and Torres Strait Islander higher education enrolments in limited fields of study is of concern as it flows through to similarly limited range of professional occupations. It highlights mathematics and science, in particular, as areas where greater involvement of Aboriginal and Torres Strait Islander people should be encouraged. Several submissions to the Review outlined the need for greater involvement in the maths and sciences – for example:

> Across all levels of education Indigenous participation in STEM [science, technology, engineering and mathematics] is well below that of non-Indigenous students, which is especially significant given the very young demographic profile of the Indigenous population (ABS 2006). ... without an appropriate level of STEM skills, Indigenous peoples' share in the opportunities of Australia's economy will be limited (submission no. 17, South Australian Department of Further Education, Employment, Science and Technology. p. 1)
>
> [T]here is an urgent need to improve Indigenous school students' exposure to and performance in mathematics. Low performance in this crucial enabling discipline excludes too many Indigenous students from university study in science, technology, engineering and mathematics (STEM) disciplines, and in Medicine, Dentistry and Veterinary Science (submission no. 16, Group of Eight, p. 13).

The Review highlighted this focus on growing Aboriginal and Torres Strait Islander involving in the STEM disciplines.

Aboriginal and Torres Strait Islander Higher Education Advisory Council

The Indigenous Higher Education Advisory Council has been replaced by a new peak advisory committee, the Aboriginal and Torres Strait Islander Higher Education Advisory Council (ATSIHEAC). The new Council will advise on implementation of the recommendations of the *Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People*, and *Closing the Gap* agreements targets.

Table 26: Summary of Indigenous policies, reports and strategies

INDIGENOUS POLICIES AND REPORTS	KEY POINTS RELEVANT TO STEM
National Indigenous Reform Agreement (COAG, 2008)	- life expectancy - mortality rates for Indigenous students under five - early childhood education

[193] Department of Industry, Innovation, Science, Research and Tertiary Education 2012, *Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People* (webpage), viewed 15 January 2013, http://www.innovation.gov.au/HIGHEREDUCATION/INDIGENOUSHIGHEREDUCATION/REVIEWOFINDIGENOUSHIGHEREDUCATION/Pages/default.aspx.

	- reading, writing and numeracy - Year 12 attainment - employment outcomes
Australian Curriculum (ACARA)	- cross-curriculum priority in Australian Curriculum
Aboriginal and Torres Strait Islander Education Action Plan 2010-2014 (MCEECDYA)	- readiness for school - engagement - attendance - literacy and numeracy - leadership - quality teaching - workforce development - pathways to post-school options
National Indigenous Higher Education Workforce Strategy (2011)	- employment pathways for existing Indigenous employees - new employment opportunities for Indigenous people - working environment - community engagement and outreach
Review of Higher Education Access and Outcomes for Aboriginal and Torres Strait Islander People (Behrendt review, 2012)	- Indigenous knowledge - Indigenous student success - professional partnerships - Indigenous higher degree by research students, researchers, university staff - university governance

STATE AND TERRITORY GOVERNMENT POLICIES AND REPORTS

As state and territory governments have responsibility under the Constitution for school education, vocational education and training and universities – institutions which are central to the STEM agenda, state and territory governments have produced a number of documents related, directly and indirectly, to STEM. This includes policies and reports aimed at:

- early childhood, primary and secondary school-level education (participation, achievement, literacy and numeracy, science and mathematics, teaching quality, curriculum, infrastructure, career planning, scientific literacy)
- vocational education and training (trade and para-professional training, VET as a pathway to employment and higher education)
- existing workforce skills development (literacy and numeracy, scientific literacy, science, mathematics and technology training)
- research and development (higher education and industry, both STEM-discipline specific and general) and
- innovation (business development and commercialisation of research).

A summary of the key STEM-related strategies identified in these documents is provided below.

Table 27: Summary of state and territory policies, reports and strategies

STATE / TERRITORY	DOCUMENT TITLE	STRATEGIES
Western Australia	*Creating a Future with Science (Final Report)* (2006)	- school-level STEM (quality curriculum resources, teacher professional development, enrichment activities, participation of under-represented students) - science, mathematics and technology-related employment outcomes (participation in VET and university STEM, quality of VET and university STEM) - science and innovation sector (STEM-qualified graduates, research infrastructure, research capabilities, partnerships)
	Productive partnerships: Advancing STEM education in Western Australian schools (2011)	- partnerships between schools and 'external STEM education providers' - STEM resources to support the introduction of the Australian Curriculum - initial teacher education - high-level STEM graduates as teachers
Queensland	*Smart Women – Smart State Strategy* (2005) and *Smart Women – Smart State Science, Engineering and*	- awareness of science, engineering and technology employment and education opportunities promoted to girls and women - industry/education partnerships - pathways to further education and employment in science, engineering and technology-related employment

	Technology Action Plan (2006-2009) (2005)	- performance measurement
	Queensland Science – Building a Smarter Future [Part 1 & 2] (2006)	- scientific research and development - community engagement with science - science-based industry/education partnerships
	Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland: Discussion paper (2007)	- science and mathematics curriculum - infrastructure - STEM-related initiatives (technology and innovation parks, skills plan, academies, science centres) - career advisory services - industry/education linkages - cross-sectoral collaborations (government, industry, education, research organisations)
	Queensland research and development investment strategy 2010-2020 (2010)	- Year 12 school science participation (STEM teacher training, curriculum and resource support, links between STEM teaching to real world applications in industry, higher education and community) - science, innovation, research and development
New South Wales	*NSW 2021 A plan to make NSW number one* (2011)	- early childhood education - literacy and numeracy - student completions - quality teaching - school autonomy - National Professional Standards for Teachers - tertiary level completions - discussing high entrance requirements and mathematics, science and English language pre-requisites for initial teacher education programs
Australian Capital Territory	*ACT Skills Future: Key initiatives in a long term strategy to address the skills challenge* (2008)	- attract high skill workers via interstate and international migration - productivity of adults (in, and outside current ACT workforce) - skill requirements (including ACT public service, health and education sectors) - post-school transitions to VET, higher education and employment - careers education
	Canberra Plan: Towards Our Secondary Century (2008)	- curriculum - teaching quality - skills training
	Pathways to the future: A report on the consultation on increasing young people's engagement in education, training and work (2009)	- school engagement - career education - pathways from school to further education, training or employment
Victoria	*Final Report: Inquiry into the Promotion of Mathematics and Science Education* (2006)	- school-level participation and achievement in science and mathematics - professional development for primary school teachers (confidence and capacity) - professional development for secondary school science teachers (content expertise, contemporary science, strategies for student engagement) - senior secondary participation in enabling sciences (cohort disparities) - contemporary science equipment (primary and secondary science education) - careers and subject selection advice - teacher supply and demand
	Energising Science and Mathematics Education in Victoria Blueprint Implementation Paper (2009)	- scientific literacy for all students - scientists and mathematicians - specialist scientific and mathematics infrastructure - cross-sectoral partnerships (industry, higher education, research organisations) - science and mathematics teacher workforce capacity - online science and mathematics curriculum resources
South Australia	*Shaping the Future – STI10: A 10-Year Vision for Science, Technology and Innovation in South Australia* (2004)	- professional, para-professional, trade and skilled graduates in areas of STEM - community engagement - career planning - high achievers into STEM education and employment - current workforce (professional development, career change) - industry making STEM careers more attractive
	Consultation paper (2012)	- primary school participation in science and mathematics - secondary school participation in STEM - pathways from school and VET to higher education STEM degrees - higher education STEM degree completions - transfers from STEM degrees to STEM higher degrees by research - STEM-skills for adults (existing workers) - succession planning - targeted immigration in STEM fields (researchers)
Tasmania	*Tasmania's Science and*	- science and technology capabilities

	Technology Policy (2001)	- industry - community benefits using science and technology - school science education - science and technology research an attractive career path
	Science and Technology Industry Plan (2004)	- science and technology human resources - science and technology teachers - workplacements - rewards - curriculum - infrastructure - community engagement
	Reaching Our Potential, Developing Tasmania's Science Research Capability (2012)	- scientific literacy - literacy in adult population - community engagement - research sector
Northern Territory	*Strategic Plan 2011-2014: Delivering a Smart Territory through Quality Education and Training* (2011)	- quality schooling - introduction of Australian Curriculum - school attendance and participation - students in remote locations - initial teacher education including Indigenous teachers - partnerships (industry, other jurisdictions, education sectors and community) - Indigenous culture - Reconciliation Action Plan to close gap in achievement

The following provides an overview of state and territory specific documentation, and policy implementation evaluation information where available. The extent to which states and territories are primarily focused on school-education and industry-led research and development, or have embraced the STEM-agenda is, in part, reflected in their education, workforce development, science and innovation policy documentation.

Western Australia

Creating a Future with Science (Final Report) (Garnett, et al. 2006[194]) was commissioned by the Western Australian Science Council. The report recommended strategies regarding quality school-level science, mathematics, engineering and technology through quality curriculum resources, teacher professional development, enrichment activities and increased participation of under-represented students. *Creating a Future with Science* also recommended strategies supporting science, mathematics and technology-related employment outcomes including increased participation in, and quality of, VET and university STEM courses. The report aimed to 'position Western Australia as a world class provider of science, mathematics, engineering and technology capability in areas of comparative advantage' (*ibid.,* n.p.) through the growth in the science and innovation sector, which it conceived of as including STEM-qualified graduates, research infrastructure and capabilities and partnerships.

In 2010 the Technology and Industry Advisory Council (TIAC) commissioned research to progress the Western Australian STEM agenda. The Western Australian Science Education Committee's report to the TIAC, *Productive partnerships: Advancing STEM education in Western Australian schools* (2011[195]) stated that:

> it is essential to develop and implement a strategy for strengthening science, technology, engineering and mathematics (STEM) education support for early childhood, primary and secondary school students and their teachers. (n.p.)

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194 Garnett, PJ, Parker, L, Robson, A, Owens, R, Chennell, K, Cook, C & Brien, A 2006, *Creating a Future with Science* (Final Report), Western Australian Science Council, Science Education Working Group. Summary cited in Science Education Committee 2011, *Productive partnerships: Advancing STEM education in Western Australian schools*, viewed 9 January 2013, http://www.tiac.wa.gov.au/Files/TIAC-Current-Publications/Science-Education-first-research-report-supplement.aspx.

195 Science Education Committee 2011, *Productive partnerships: Advancing STEM education in Western Australian schools*, viewed 9 January 2013, http://www.tiac.wa.gov.au/Files/TIAC-Current-Publications/Science-Education-Committee-first-research-report.aspx.

The report framed the importance of STEM education in terms of enhancing community scientific literacy, and preparation for STEM-related employment within the Western Australian context of a positive economic outlook. *Productive partnerships* discussed the introduction of the Australian Curriculum for sciences and mathematics and stated that:

> a curriculum change will not be sufficient. Investments in enabling support, including professional development and resources, will be required for optimum outcomes. Such investments are more likely to occur when there are productive partnerships between the formal education system and the external providers. (ibid, n.p)

Productive partnerships recommended that formal STEM education provided by schools (that is, science and mathematics) be supplemented by STEM-related activities offered by 'external STEM education providers' (*ibid*, n.p.). Potential providers identified included government agencies, universities, organisations such as the Museum and Zoo, and independent bodies such as local councils and private businesses. In addition to establishing cross-sectoral partnerships, the report recommended the development of STEM resources to support the introduction of the Australian Curriculum, and the implementation of teaching quality strategies including professional development, initial teacher education and attracting high-level STEM graduates to the teaching profession.

The Technology and Industry Advisory Council (TIAC) strategic plan*, The way ahead – A work plan for TIAC* (2012[196]), committed TIAC to 'Undertake a research project to formulate a strategy and recommendations for the State Government to strengthen science, technology, engineering and mathematics (STEM) education in Western Australian schools through the enhancement and optimisation of formal and external STEM education support' (n.p). The *Productive partnerships* report and supporting volume (2011[197]) forms one part of this initiative.

Queensland

The Queensland government's *Smart Women – Smart State Strategy* (2005) aimed to redress women's under-representation in science, technology and engineering fields of employment. The subsequent *Smart Women – Smart State Science, Engineering and Technology Action Plan (2006–2009)* (Queensland Government, 2005[198]) identified priorities including promoting science, engineering and technology employment and education opportunities to girls and women, developing education industry partnerships, building pathways to further education and employment in science, engineering and technology-related employment and performance measurement. The strategy supported the broader *Smart State Strategy* (2005-2015).

The Queensland Chief Scientist explored ways in which increased investment in scientific research and development might contribute to state development in *Queensland Science – Building a Smarter Future [Part 1 & 2]* (2006[199]), and further position Queensland as the smart state. The report established a vision whereby 'In 2025, the proportion of (science, engineering and technology)-qualified workers in

196 Technology Industry Advisory Council 2012, *The way ahead – A work place for TIAC*, viewed 9 January 2013, http://www.tiac.wa.gov.au/Files/TIAC-Current-Publications/The-Way-Ahead--A-work-plan-for-TIAC--final-version.aspx.

197 Science Education Committee 2011, *Productive partnerships: Advancing STEM education in Western Australian schools Supporting volume*, viewed 9 January 2013, http://www.tiac.wa.gov.au/Files/TIAC-Current-Publications/Science-Education-first-research-report-supplement.aspx.

198 Queensland Government 2005, *Smart Women – Smart State Science, Engineering and Technology Action Plan (2006–2009*, Queensland Government, Brisbane, viewed 9 January 2013, http://www.communities.qld.gov.au/resources/women/work-and-life/set-action-plan.pdf.

199 Queensland Chief Scientist 2006, *Queensland Science – Building a Smarter Future (Part 1 & 2)*, Queensland Government, Brisbane, viewed 5 January 2013, http://www.chiefscientist.qld.gov.au/publications/building-smart-future/assets/qld-science-building-a-smarter-future.pdf.

Queensland will have surpassed that of leading OECD economies, inspiring innovation in both established and emerging industries' (*ibid.,* p. 4). The report supported increased investment in scientific research and development, general community engagement with science, and science-based industry/education partnerships.

The then Premier, Anna Bligh subsequently stated in *Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland: Discussion paper* that 'science, technology, engineering and mathematics (STEM) education and skills development plays an important role in the Smart State vision' (Department of Education, Training and the Arts, 2007, foreword)[200]. The discussion paper posed a series of questions about the nature of STEM, science and mathematics curriculum, infrastructure and potential strategies, and identified Queensland's key STEM-related initiatives, including technology and innovation parks, the *Queensland Skills Plan*, Queensland Academies and Science Centres. The discussion paper reported comprehensive student participation and achievement data, teacher workforce and qualifications data and labour market information. STEM-related strategies identified include: careers advisory services, linkages between schools and industry, and collaboration between government, industry, education and research organisations.

The Queensland government's *Queensland research and development investment strategy 2010-2020* (2010)[201] recognised the relationship between research and development, and science and innovation and committed the government to reversing declining Year 12 science participation through 'investments in STEM teacher training, curriculum and resource support, and linking STEM teaching and learning directly to real world applications in industry, higher education and the broader community' (*ibid.,* p. 20). In establishing a far-reaching strategy spanning science, innovation, research and development, Queensland government STEM-related initiatives are quite explicitly focused on the pipeline into high-end research and development.

New South Wales

The NSW Government's statement, *NSW 2021 A plan to make NSW number one* (2011)[202] aimed to leverage NSW's competitive advantages by 'improv(ing) education and learning outcomes for all students' (*ibid*, n.p.). Amongst other things in a broad ranging document covering transport, health, family and community services, education, police, infrastructure, environment and government accountability, the plan prioritised early childhood education, literacy and numeracy, student completions, quality teaching and increased school autonomy. The plan committed to supporting the introduction of the *National Professional Standards for Teachers* developed by the Australian Institute for Teaching and School Leadership (AITSL) and supported increased tertiary level qualification completions (*ibid*., p. 14).

As noted earlier, in terms of strategies to address teaching quality issues, the *Great Teaching, Inspired Learning: Discussion Paper* (NSW Government, *op cit*.) proposed establishing high minimum Australian Tertiary Education Rank (ATAR) requirements and

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[200] Department of Education, Training and the Arts, 2007, *Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland: Discussion paper,* Queensland Government, Brisbane, viewed 1 January 2013, http://education.qld.gov.au/projects/stemplan/docs/stem-discussion-paper.pdf.

[201] Department of the Premier and Cabinet 2010, *Queensland research and development investment strategy 2010-2020*, Queensland Government, Brisbane, viewed 1 January 2013, http://www.chiefscientist.qld.gov.au/publications/building-smart-future/assets/queensland-r-and-d-investment-strategy-2010-2020.pdf.

[202] NSW Government 2011, *NSW 2021 A plan to make NSW number one*, NSW Government, Sydney, viewed 2 January 2013, http://www.2021.nsw.gov.au/.

mathematics, science and English language pre-requisites for entry to initial teacher education programs. This issue is currently being considered.

Australian Capital Territory

The Australian Capital Territory has released a number of inter-related policies and plans that focus on maintaining the territory's competitive advantage with respect to education, workforce and economic development. *ACT Skills Future: Key initiatives in a long term strategy to address the skills challenge* (Chief Minister's Department, 2008[203]) reflected the ACT Skills Commission advice that 'the ACT needs more people, and more people with higher level skills' (*ibid*., p. 3). The plan also reported that Access Economics demographic predictions show that without significant policy interventions the ACT's long-term rate of growth will be less than the national average' (*ibid*., p. 13). *ACT Skills Future* identified demographic concerns including the declining population growth rate, low immigration (other than young people in the age bracket 15-24), declining workforce participation and the large proportion of the workforce with no post-compulsory education qualifications. *ACT Skills Future* focused on attracting high skill workers to the ACT via interstate and international immigration, increasing the productivity of adults including those in, and outside, the current ACT workforce, and strategies to address skill requirements, particularly in the ACT Public Service, and the health and education sectors. The plan also identified strategies for improving post-school transitions to vocational education and training, higher education and employment, including recognition of the importance of improved careers education.

The ACT government then released the *Canberra Plan: Towards Our Second Century* (2008[204]), which established a vision for Canberra through strategies including health care, safe communities, education and training, the economy, a vibrant city, a sustainable future and quality services. In terms of education and skills development, the *Canberra Plan* established a series of strategies that complement COAG's productivity reforms (for example, curriculum, teaching quality, skills training). The subsequent evaluation, *ACT skills future progress report* (ACT Government, 2009[205]) identified initiatives completed to address those aims, and noted the COAG national agreements in related areas. In terms of labour market shortages, the evaluation noted that 'At this time skills shortages continue to act as a constraint on ACT employment growth across some sectors. However, initiatives in the future will be designed to optimise employment outcomes for skilled migrants without jeopardising opportunities for local residents' (*ibid*., p. 15).

The *Pathways to the future: A report on the consultation on increasing young people's engagement in education, training and work* (Department of Education and Training, 2009[206]) noted that the ACT government had committed to 'increasing to 95 percent, the proportion of 19 year olds with a Year 12 Certificate or equivalent vocational qualification by 2013' (p. 1). This target is higher than the COAG agreed retention rate target. The report also reflected on consultations that recommended strategies to enhance school engagement, career education, and pathways from school to further education, training or employment.

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203 Chief Minister's Department 2008, *ACT Skills Future: Key initiatives in a long term strategy to address the skills challenge.* ACT Government, Canberra, viewed 4 January 2013, http://www.cmd.act.gov.au/policystrategic/archive/skills.

204 ACT Government 2008, *Canberra Plan: Towards Our Second Century*, ACT Government, Canberra, viewed 5 January 2013, http://www.cmd.act.gov.au/policystrategic/canberraplan.

205 ACT Government 2009, *ACT skills future progress report*, viewed 5 January 2013, http://www.cmd.act.gov.au/__data/assets/pdf_file/0006/119733/skills-report.pdf.

206 Department of Education and Training 2009, *Pathways to the future: A report on the consultation on increasing young people's engagement in education, training and work*, ACT Government, Canberra, viewed 2 January 2013, http://www.det.act.gov.au/__data/assets/pdf_file/0007/30679/Pathways_to_the_Future.pdf.

Victoria

The Parliament of Victoria Education and Training Committee *Final Report: Inquiry into the Promotion of Mathematics and Science Education* (2006) found variability in school-level participation and achievement in mathematics and science (that is, cohort differences based on SES, gender and geographical location; and resulting from difference in terms of teaching quality, infrastructure and equipment). The report recommended increasing school-level participation and achievement in science and mathematics and established a vision for 'a level of mathematical and scientific literacy that matches the best in the world by 2020 and to increase the proportion of our highest achievers pursuing these disciplines' (*ibid*., p. 1).

Key recommendations concerned professional development for primary school teachers to enhance confidence and capacity in delivering mathematics and science education and professional development for secondary science school teachers regarding content expertise, contemporary science, and strategies for student engagement. In addition, the inquiry recommended increasing senior secondary student participation in the enabling sciences (including addressing cohort disparities), the installation of contemporary science equipment for primary and secondary science education, careers and subject selection advice and addressing teacher supply and demand (*ibid*.).

The subsequent government strategy, *Energising Science and Mathematics Education in Victoria Blueprint Implementation Paper* (Department of Education and Early Childhood Development, 2009[207]) stated that 'success in the global workplace will require 21st-century education systems that increase performance in the stem (Science, Technology, Engineering and Mathematics) disciplines' (p. 5). The strategy is directed towards scientific literacy for all students, and capacity for 'a strong pool of talented scientists and mathematicians to advance technological and scientific boundaries' (*ibid*., p. 5). The strategy focused on building specialist scientific and mathematics infrastructure, partnerships with industry, higher education, research organisations, science and mathematics teaching workforce capacity and online science and mathematics curriculum resources.

The Victorian Auditor-General subsequently completed an audit of the Victorian Department of Education and Early Childhood Development (DEECD) initiatives concerning science and mathematics and produced a critical report, *Science and Mathematics Participation Rates and Initiatives: Victorian Auditor General's Report*, stating that:

> DEECD has not succeeded in raising achievement in science and mathematics or participation in the enabling sciences, despite a 2006 Victorian Parliamentary inquiry which found that it needed to lift participation and performance. Three years after the inquiry, DEECD released the science and mathematics education strategy but implementation of various initiatives has been slower than anticipated, and their impact small. DEECD will need to improve its planning, coordination and oversight and develop greater accountability at the school level if science and mathematics participation and achievement are to improve. … DEECD lacks essential data, has failed to develop a robust workforce strategy, and its teacher recruitment and professional learning initiatives have had little, if any, impact on the quality of science and mathematics teaching and learning. This seriously compromises the future supply of science and mathematics skills and knowledge in the community.

[207] Department of Education and Early Childhood Development 2009, *Energising Science and Mathematics Education in Victoria Blueprint Implementation Paper*, Victorian Government, Melbourne, viewed 5 January 2013, http://www.education.vic.gov.au/Documents/about/programs/learningdev/energisingmathscipaper.pdf.

(Victorian Auditor-General, 2012, p. vii[208])

The audit highlighted concerns regarding the low levels of student achievement in school science and mathematics, disengagement, disparities in terms of school location (metropolitan, rural and regional), teaching quality, science and mathematics qualified teacher supply and science and mathematics infrastructure. The audit concluded that:

> The immediate challenge is for schools to use the new science infrastructure to implement a contemporary science curriculum, extend strategic partnerships with industry, higher education and specialist facilities, and to engage more students and lift achievement'. (ibid., p. viii)

South Australia

The South Australian strategy, *Shaping the Future—STI10: A 10 - Year Vision for Science, Technology and Innovation in South Australia* (Department of Further Education, Employment, Science and Technology, 2004[209]) established a holistic STEM strategy spanning all levels of education, young people and the existing workforce, and high-end STEM research and development. The strategy established a goal: 'by 2020 … to supply South Australian employers with an increased source of professional, para-professional, trade and skilled graduates qualified in relevant areas of STEM' (p. 4). The strategy established a collaborative decision-making structure for funding injections and a formal evaluation process. *Shaping the Future* established priorities including community engagement, career planning, encouraging high achievers into STEM education and employment, focusing on the current workforce (professional development or career change to STEM-related professions), and encouraging industry to make STEM careers more attractive.

The strategy is currently under review by the South Australian Premier's Science and Industry Council. The review *Consultation paper* (Premier's Science and Industry Council, 2012[210]) examined strategies including increasing primary and secondary student participation in STEM, enhancing pathways into STEM higher education from school and vocational education and training, supporting completions and transfer to higher degree by research, STEM skill development for adults (existing workers) in related fields, succession planning and targeted immigration to complement the research workforce (p. 7). The consultation is pitched broadly, spanning primary and secondary school, university and vocational education and training, and young people and existing workers.

Tasmania

The Tasmanian government's statement *Tasmania's Science and Technology Policy* (2001[211]) established the following goals: 'strengthen Tasmania's science and technology capabilities; and develop Tasmanian industry and achieve community and other benefits

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208 Victorian Auditor-General 2012, *Science and Mathematics Participation Rates and Initiatives*, Victorian Government, Melbourne, viewed 5 January 2013, http://www.audit.vic.gov.au/publications/20120606-Science-and-Maths/20120606-Science-and-Maths.html.

209 Department of Further Education, Employment, Science and Technology 2004, *Shaping the Future – STI10: A 10-Year Vision for Science, Technology and Innovation in South Australia,* South Australian Government, Adelaide, viewed 1 January 2013, http://www.dfeest.sa.gov.au/Portals/1/Documents/science/STEM_Skills_Strategy_for_South_Australia.pdf.

210 Premier's Science and Industry Council 2012, *Consultation paper*, South Australian Government, Adelaide, viewed 1 January 2013, http://www.dfeest.sa.gov.au/Portals/1/Documents/science/SRII%20Consultation%20paper%20-%20final%203%20Dec%2010.30am.pdf.

211 Department of State Development 2001, *Tasmania's Science and Technology Policy*, Tasmanian Government, Hobart, viewed 2 January 2012, http://www.development.tas.gov.au/science/science_and_technology/science_and_research/science_and_technology_council.

using science and technology in Tasmania' (p. 6). Strategies included enhancing school science education, producing the 'science and technology skill base required by industry and the community … and (ensuring) attractive career paths for those with science and technology research and development skills' (*ibid*., p. 7).

The subsequent *Science and Technology Industry Plan* (Tasmanian Science and Technology Council, 2004[212]) confirmed the priorities of building science and technology human resources (that is, science and technology teachers, workplacements, rewards, curriculum and infrastructure) and increasing community appreciation of science and technology. A proposed activity included the establishment of an Office of the Chief Scientist. In terms of the state's agenda for science and innovation, the Tasmanian government has recently released the statement *Reaching Our Potential, Developing Tasmania's Science Research Capability* (Department of Economic Development, Tourism and the Arts, 2012[213]). The plan identified the limitations of school education: 'more and more young people are not pursuing a basic level of scientific literacy through their formal education. Furthermore, only about 50 per cent of Tasmanian adults exhibit adequate general literacy levels' (*ibid*., p. 7), and established an objective of both increased community engagement with science research, and an enhanced science research sector.

Northern Territory

Reflecting the unique challenges faced by the Northern Territory in terms of comparative underperformance and inequities for Indigenous and remotely located people, the Northern Territory Department of Education *Strategic Plan 2011-2014: Delivering a Smart Territory through Quality Education and Training* (2011[214]) focused largely on quality school education. Amongst other things, strategies concerned the introduction of the Australian Curriculum, school attendance and participation, access for students in remote locations, initial teacher education including remote Indigenous teacher training and partnerships involving industry, other jurisdictions, education sectors and the community. The plan also committed to 'understanding and celebrating our Indigenous culture: all schools will work with their community to develop t-9 programs that focus on building a better understanding and appreciation of territory and local Indigenous culture' (*ibid*., n.p.), and developing a Reconciliation Action Plan to close the gap between Indigenous and non-Indigenous students.

CONCLUSION

Despite the plethora of government policies and reviews focused on school education, and science and innovation and the recent emergence of the STEM agenda in Australia, there is currently no Commonwealth 'Science, Technology, Engineering and Mathematics (STEM) Policy'. Furthermore, in the policy documentation examined there appears to be only limited coherence between Commonwealth policy interventions and state and territory policies and programs other than where COAG national agreements are in place. As expected, there is great variation between state and territory approaches to STEM-specific and/or education, skills development and R&D policies, reflecting differing priorities, contexts and requirements. However, the policy documentation

[212] Tasmanian Science and Technology Council 2004, *Science and Technology Industry Plan*, Tasmanian Government, Hobart, viewed 2 January 2013, www.development.tas.gov.au/__data/assets/pdf_file/0018/3861/TasmanianScience_and_TechnologyIndustryPlan.pdf.

[213] Department of Economic Development, Tourism and the Arts 2012, *Reaching Our Potential, Developing Tasmania's Science Research Capability,* Tasmanian Government, Hobart, viewed 2 January 2013, http://www.development.tas.gov.au/science/science_and_technology/science_and_research/about_us.

[214] Department of Education 2011, *Strategic Plan 2011-2014: Delivering a Smart Territory through Quality Education and Training*. Northern Territory Government, Northern Territory Government, Darwin, viewed 9 January 2013, http://www.det.nt.gov.au/__data/assets/pdf_file/0013/4126/DET_StrategicPlan.pdf.

examined suggests a dislocation between national agendas concerning key STEM-related initiatives, such as implementation of the Australian Curriculum and Australian Professional Standards for Teachers.

The ‘pipeline’ is decreasing. Participation in senior secondary school science is decreasing in each of the enabling sciences - biology, chemistry and physics. Participation in senior secondary school mathematics is decreasing, alongside a trend towards easier mathematics courses. Whilst universities have manipulated pre-requisites to attract high achieving students and provide increased access to disadvantaged cohorts, there is a point at which reduced foundational knowledge in the enabling sciences and mathematics limits study and career prospects.

Participation in university undergraduate and higher degree by research programs in STEM-disciplines is only marginally increasing, due largely to the significant increases in Health which have masked persistent declines in Information Technology, and only marginal increases in Engineering and Natural and Physical Sciences. Whilst a significant proportion of vocational education and training (VET) sector students participate in STEM-disciplines, most enrol in low AQF-level courses, thereby forestalling their participation in high-end STEM occupations. Despite more women than men participating in both the vocational education and training (VET) sector and higher education generally, there remains a persistent gender disparity in many STEM-disciplines, principally including Information Technology and Engineering.

Performance in school-level science is fluctuating. It is certainly not improving to the extent that our international comparators and neighbours are. Performance in school-level mathematics is declining, whilst that of several of our international comparators and neighbours is increasing. There are persistent discrepancies in student performance between the states and territories, with students in the Australian Capital Territory consistently recording the highest achievement, and students in the Northern Territory the lowest. The gap is wide. The long tail of underperformance in science, mathematics, scientific literacy, and literacy and numeracy more generally for several cohorts, particularly Indigenous students, students in remote and very remote locations and students with disability, is of great concern.

Whilst it would appear that the ‘crisis’ with respect to teacher supply has diminished somewhat, the limited data on graduating teacher numbers and teacher shortages makes assertions regarding teacher supply problematic. The professional associations maintain that shortages are endemic. However what is clear is that there are large numbers of secondary teachers teaching mathematics out of field, and there are serious questions regarding arrangements whereby primary teachers without discipline-specific training are required to deliver primary school level science and mathematics curriculum without sufficient support and professional development.

There are challenges facing Australia’s research and development and innovation sector; there have been repeated calls for further funding injections. There appear to be national labour market shortages in some STEM-occupations, most notably engineering. The skill levels of a large proportion of the existing workforce and the unemployed in terms of literacy and numeracy are alarming.

Australia’s comprehensive performance monitoring systems, particularly for school-level education, now provide a graphic illustration of the nature and depth of these concerns.

Where the Commonwealth government agrees to embrace the STEM agenda, a coherent ‘Science, Technology, Engineering and Mathematics (STEM) Policy’ spanning all Commonwealth, state and territory governments, education systems and industry, including strategies pitched at early childhood, school, VET, higher education and research and development for students, adults and business could go some way to addressing these challenges.