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## STEM education in NSW schools

by Tom Gotsis

### 1. Introduction

In Australia and internationally, school education policy is focused on improving STEM (Science, Technology, Engineering and Mathematics) outcomes. This focus is principally driven by an economic agenda that views a nation's STEM capacity as critical for future innovation, productivity and economic growth.<sup>1</sup> Yet Australian school students are more disengaged with mathematics and science than their international peers. The rate at which they participate in STEM subjects has also decreased. Since 1995, the STEM performance of Australia's school students has, in general, declined; both in absolute terms and relative to many other nations.

This e-brief discusses recent joint national and NSW reforms designed to improve STEM school education outcomes. The national reforms include the launch of the [National Innovation and Science Agenda](#) on 7 December 2015<sup>2</sup> and the endorsement of the [National STEM School Education Strategy 2016–2026](#) by Education Ministers on 11 December 2015.

Unlike Queensland,<sup>3</sup> South Australia<sup>4</sup> and Victoria,<sup>5</sup> NSW does not have a stand-alone STEM education strategy. Nevertheless, developing STEM education is a key feature of the [NSW Innovation Strategy](#). NSW has also implemented the [National STEM School Education Strategy 2016–2026](#) by: developing online [STEM resources](#); establishing “STEM Action Schools”; funding additional infrastructure; introducing minimum standards for the HSC; strengthening teaching standards; and reforming the curriculum.

This e-brief also discusses three concerns that have been expressed about the renewed focus on STEM education. Firstly, that encouraging more students to pursue STEM education is a purely supply-side intervention that, on its own, will lead to an oversupply of STEM graduates. Secondly, that the use of the term STEM hinders efforts to direct students towards occupations where existing or anticipated skills shortages have been identified. Thirdly, that a focus on STEM education will devalue the ideal of a comprehensive education and, consequently, produce graduates who lack the creativity, critical thinking, social intelligence and entrepreneurialism that are expected to be increasingly valuable in the employment market.

## 2. What is STEM?

STEM encompasses a vast range of knowledge across all stages of learning: pre-school,<sup>6</sup> primary and secondary school, Vocational Education and Training (VET) and university. An indication of the breadth of STEM education at the school, VET and university levels is set out in Table 1.

**Table 1: A selection of STEM education subjects across school, VET and university\***

	Science	Technology	Engineering	Mathematics
<b>School</b>	Biology Chemistry Environmental Physics	Design and Technology Food Technology Industrial Technology Information Technology	Engineering Studies	Mathematics
<b>VET</b>	Agriculture Aquaculture Laboratory Skills Horticulture	Air conditioning/refrigeration Automotive electronics Electro-technology Light Vehicle Mechanical	Applied Engineering (Renewable Energy) Engineering: Fabrication Engineering: Mechanical	Mathematics and Science for Further Study
<b>University</b>	Astronomy Microbiology Chemistry Quantum Physics Zoology	Construction Technology Information Technology Robotics Technology (Aviation)	Aeronautical Engineering Chemical Engineering Civil Engineering Electrical Engineering Mechanical Engineering	Mathematics

\* For more STEM subjects, see: Office of the Chief Scientist, [Australia's STEM Workforce](#), 2016, Appendix A

As commented upon by the Australian Council of Learned Humanities, the scope of the term STEM creates difficulties in formulating, implementing and evaluating STEM policy; although, at the school level, core STEM subjects are easier to identify:

[T]he discipline grouping, and the term itself, are not used uniformly in international educational policy or practice. ... In much discussion of STEM both in Australia and in other jurisdictions, it appears that science, engineering and related technologies, and mathematics, are seen as a de facto core. Medicine and health sciences ... are marginal to this core or are not always included.

This core notion of STEM poses problems for policy in Australia because compared to some comparator countries (e.g. Finland, Korea), Australia has a large workforce in health services and a small workforce in manufacturing and the engineering professions. ... At school the foundational preparatory practice of STEM — in the form of the science and mathematics disciplines — remain relevant whether STEM is conceived broadly or narrowly.<sup>7</sup>

Adding to these difficulties, STEM education refers to teaching methodology, as well as subject area. In an effort to promote student engagement and reflect the real-world application of STEM knowledge, a defining feature of STEM education is the use of both traditional pedagogy and interdisciplinary, group-based project work.<sup>8</sup>

In light of the breadth of the underlying concept, stakeholders such as Engineers Australia and the National Centre for Vocational Education Research argue that, rather than promoting STEM education, it would be more effective to encourage students to pursue specific STEM occupations where existing or anticipated skills shortages have been identified.<sup>9</sup>

## 3. The benefits of STEM education

### 3.1 Economic benefits of STEM education

Australia has set itself the ambitious target of being placed, by 2025, in the top five countries based on the performance of its school students in reading, mathematics and science.<sup>10</sup> Despite such ambitious targets, the underlying objective of STEM education is not to produce students who are able to perform well in standardised tests. Instead, the underlying objective of STEM education is “closely tied to an overall economic agenda”.<sup>11</sup> The *National STEM School Education Strategy 2016–2026* expressly refers to STEM education as promoting employment and economic growth.<sup>12</sup>

#### 3.1.1 Employment

Viewing the labour market as a whole, employment prospects for STEM graduates in Australia tend to be better than those of non-STEM graduates. As detailed in Table 2, in 2011 the unemployment rate of STEM qualified people was lower than the unemployment rate of non-STEM-qualified people across Australia and in all jurisdictions except for the ACT and Tasmania.<sup>13</sup>

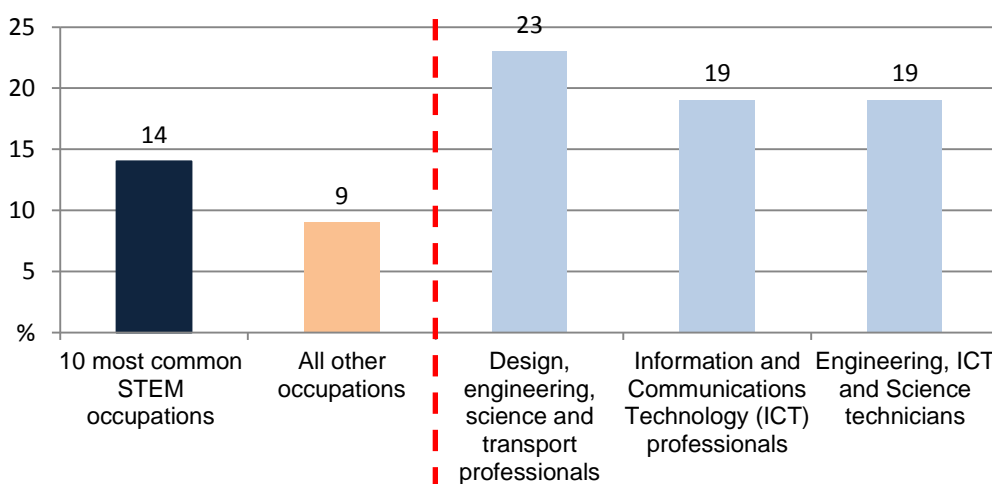
**Table 2: Unemployment rate by highest post-secondary qualification, 2011\***

Jurisdiction	Total STEM	Total Non-STEM	Total population
NSW	3.9	4.3	5.2
VIC	3.8	4.0	5.1
QLD	3.8	4.6	5.8
SA	4.0	4.1	5.8
WA	2.9	3.5	4.2
TAS	4.6	4.1	5.2
NT	2.5	2.7	3.3
ACT	2.5	2.3	3.8
AUS	3.7	4.1	5.1

\* Population aged 15–64 years, highest post-secondary qualification stated/adequately described.  
Source: Office of the Chief Scientist, *Australia's STEM Workforce*, 2016, p 24.

Additionally, Figure 1 supports the proposition that STEM jobs are of “growing importance”<sup>14</sup> to Australia’s labour market.<sup>15</sup>

**Figure 1: Growth in employment between 2006 and 2011, Australia**



Source: Australian Bureau of Statistics, *Perspectives on Education and Training*, 2014

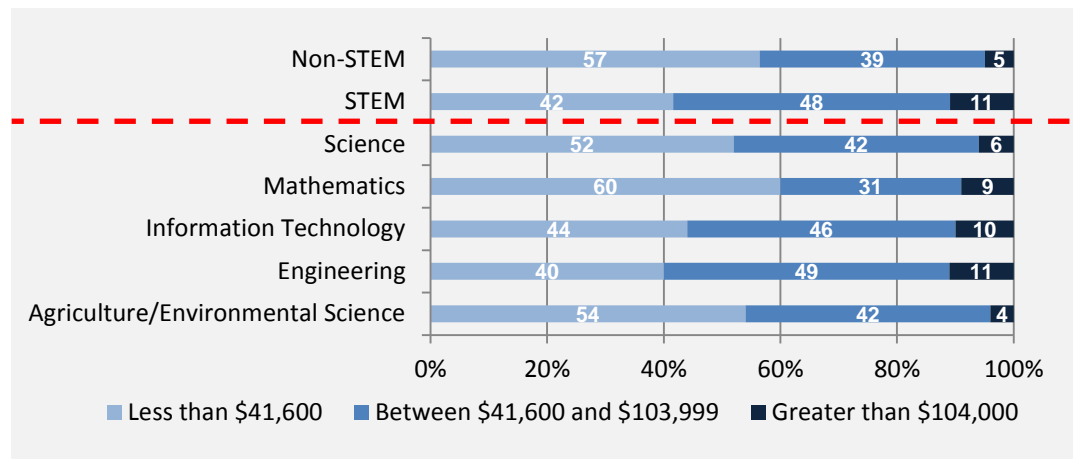
*Jobs for NSW* has similarly commented on the increasing importance of STEM jobs in the NSW labour market over the period 1996–2015:

the traditional professions are fast being overtaken by two groups that are laying down the digital and physical infrastructure of the 21st century. Jobs in computer system services have grown at 7% compound for 20 years, and now make up 2% of our workforce. Our engineering, architecture and technical services have grown at a 4.5% compound rate to now make up 2.3% of our workforce.<sup>16</sup>

### 3.1.2 Growth in personal and national income

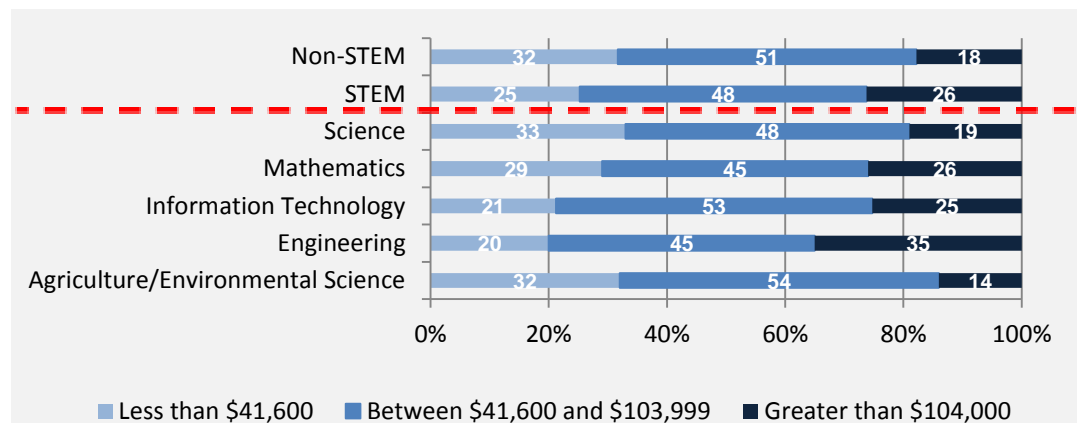
As set out in Figures 2 and 3, Australian workers with STEM skills tend to enjoy higher personal incomes than workers without STEM skills.<sup>17</sup>

**Figure 2: Personal income of people with VET qualifications, by field\***



\*Certificate to advanced diploma. Due to rounding of numbers some percentages may not add to 100%  
Source: Office of the Chief Scientist, [Australia's STEM Workforce](#), 2016, p 31

**Figure 3: Personal income of people with university qualifications, by field\***



\* Bachelor degrees and above. Due to rounding of numbers some percentages may not add to 100%  
Source: Office of the Chief Scientist, [Australia's STEM Workforce](#), 2016, p 31.

STEM skills also increase national income, as they underpin much of the economic activity in technologically advanced societies. For instance, in Australia in 2012–13 the biological, physical and mathematical sciences directly and indirectly provided over 26 per cent of Australia's economic activity, which equated to about \$330 billion per year.<sup>18</sup> Economic modelling suggests that growing Australia's STEM workforce by 1% would add \$57.4 billion to GDP (net present value over 20 years).<sup>19</sup>

### 3.1.3 Innovation

STEM education fosters innovation by developing a “range of generic and quantitative skills and ways of thinking that enable individuals to see and grasp opportunities”.<sup>20</sup> In turn, as emphasised in the [National Innovation and Science Agenda Report](#), innovation fosters economic growth:

Innovation and science are critical for Australia to deliver new sources of growth, maintain high-wage jobs and seize the next wave of economic prosperity. ... Innovation keeps us competitive. It keeps us at the cutting edge. It creates jobs. And it will keep our standard of living high.<sup>21</sup>

Attempts to quantify the extent to which innovation contributes to economic growth indicate that scientific and technological advances have produced roughly half of all US economic growth in the last 50 years.<sup>22</sup> In Australia, between 1964 and 2005, 65 per cent of economic growth per capita has been due to improvements in the use of capital, labour and technological innovation.<sup>23</sup>

### 3.2 Non-economic benefits of STEM education

The non-economic benefits of STEM education, although not measurable, are profound. This is because, ultimately, STEM education enables individuals and societies to better understand and engage with the world in which they live in, and respond creatively and effectively to emerging challenges they face.<sup>24</sup> As Professor Richard Larson, from MIT University, states, a STEM-literate person:

can understand the world around her in a logical way guided by the principals of scientific thought. A STEM literate person can think for herself. She asks critical questions. She can form hypotheses and seek data to confirm or deny them. She sees the beauty and complexity in nature and seeks to understand. She sees the modern world that mankind has created and hopes to use her STEM-related skills and knowledge to improve it.<sup>25</sup>

## 4. Have the benefits of STEM education been overstated?

### 4.1 Should we have STEAM instead of STEM?

In Australia and overseas, concerns have been raised that focusing on STEM education will undermine the goal of providing all students with a comprehensive education.<sup>26</sup> Many of these concerns have been expressed under the banner of STEAM (Science, Technology, Engineering, Arts and Mathematics). Internationally, STEAM has been embraced by the educationally high-performing nation of South Korea, which has developed:

a decisive curriculum response to a perception that students were not finding the STEM curriculum engaging, and that the curriculum was not addressing the objective of creativity. Korea is especially concerned about teaching strategies and approaches, and determined to improve the creativity, artistic and innovative flair of students in STEM employment. Towards this end the country has developed a ‘STEAM’ curriculum with the creative ‘Arts’ embedded in STEM to enhance student engagement and encourage creativity. This is intended to emulate the philosophy of past Apple CEO Steve Jobs, that infinite imagination and divergent thinking, more than technological advances or industrial structures, define success in technology, including engineering and engineering design, and innovation in science.<sup>27</sup>

*Jobs for NSW* has similarly endorsed combining strong STEM skills with a broad education in order to foster creativity, social skills and critical thinking:

In the age of digital machines, we need not only the science, technology, engineering and mathematics (STEM) capabilities that are rightly being emphasised in our schools. We also need to strengthen the social-emotional and problem-solving skills, and become better at applying those skills to our specialised knowledge and roles.

Those who have studied the issue have a solid, shared idea of what those skills are: digital literacy, communication skills, critical thinking, problem-solving skills, creative thinking, entrepreneurial skills, team work, intercultural competence and the like. But few can agree on the best adjective to describe them collectively.<sup>28</sup>

A comprehensive education, one that fosters the “intellectual, social and moral development of students”,<sup>29</sup> remains the primary goal of education. The [National STEM School Education Strategy 2016–2026](#) expressly states that “STEM sits within a broader foundational knowledge base and the teaching of STEM is a part, albeit important, of a balanced program of learning”.<sup>30</sup> The *Education Act 1990* provides for the following Key Learning Areas until the end of Year 10: English; Mathematics; Science; Human Society and its Environment; Personal Development, Health and Physical Education; Languages; Technological and Applied Studies; and Creative Arts.<sup>31</sup> English remains the only subject that is compulsory to Year 12.<sup>32</sup>

### 4.2 Will there be enough jobs for STEM graduates?

STEM education is a purely supply-side measure that, on its own, will not cause demand for STEM skills to “spontaneously appear”.<sup>33</sup> Accordingly, the [National Innovation and Science Agenda](#) and [NSW Innovation Strategy](#) adopt a broad policy perspective; one that promotes STEM education while simultaneously encouraging research and innovation across the university, business and government sectors.<sup>34</sup>

Ultimately, however, the question of whether or not there will be a sufficient number of STEM jobs for STEM graduates cannot be answered conclusively. Labour market forecasts are valuable but not definitive; particularly in circumstances where “[f]orty per cent of today’s jobs will not exist in 10 to 15 years, and 60 per cent of the best jobs in the next 10 years have yet to be invented”.<sup>35</sup> Adding to this uncertainty, STEM skills are transferrable and enable STEM graduates to work in many non-STEM occupations;<sup>36</sup> occupations which are often better paid or offer better career opportunities than STEM occupations.<sup>37</sup> Moreover, as STEM spans such a broad range of fields across both the university and VET sectors, there is a large degree of over-simplification in viewing the labour market as a whole.<sup>38</sup> In short, there might be enough jobs for some STEM graduates but not others. For instance, in 2015 the unemployment rate four months after graduation for life scientists, mathematicians and chemists was nearly 20%, while the overall average graduate unemployment rate was 12.5%.<sup>39</sup>

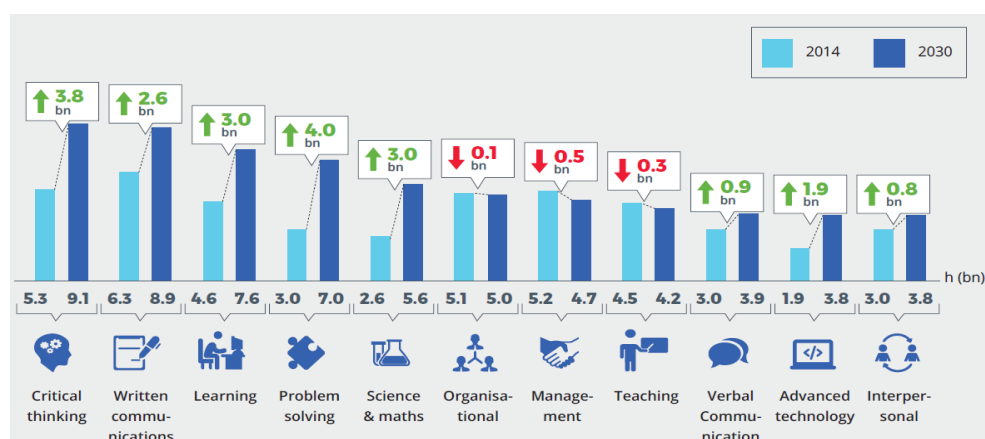
Adding to this uncertainty, domestic STEM skill shortages are readily filled by organisations hiring foreign STEM-skilled workers or relocating all or some of their operations overseas.<sup>40</sup> For instance, Engineers Australia has reported that “permanent migration of engineers has been higher than domestic student university education completions since 2009 ... [and] accounts for almost two-thirds of our new engineers”.<sup>41</sup> The Commonwealth

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Government stated in its 2015 National Innovation and Science Agenda Report that it will “support all Australian students to embrace the digital age” and “change the visa system to attract more entrepreneurial and research talent from overseas.”<sup>42</sup>

The Foundation for Young Australians (FYA) has taken a longer-term perspective; one that seeks to account for the likely effects of automation and globalisation. As set out in Figure 4, FYA forecasts that, between 2014 and 2030, the need for core STEM skills will increase; as will the need for such skills as critical thinking, problem solving, interpersonal skills and written communication.<sup>43</sup>

**Figure 4: Skills use (billion hours of work across economy), 2014 and 2030**



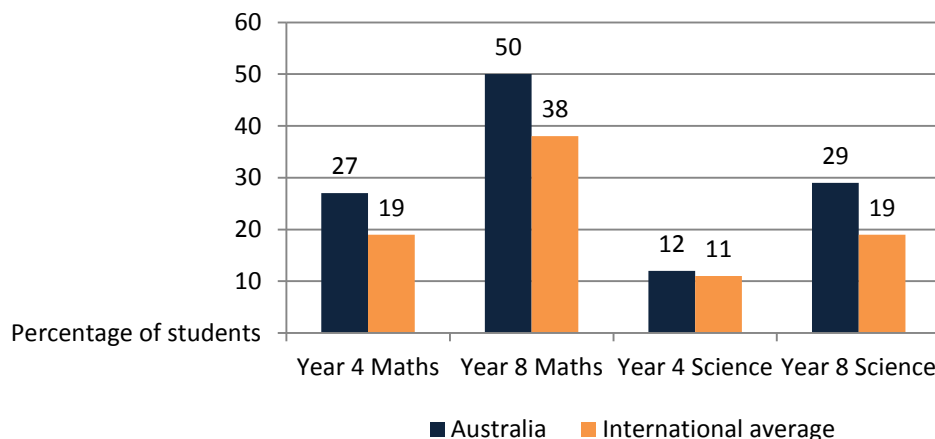
Source: FYA, *The New Work Smarts*, 2017, p 21

## 5. STEM outcomes: engagement, participation, and performance

### 5.1 Engagement

Set out in Figure 5 are responses to questions issued as part of the 2015 Trends in International Mathematics and Science Study (TIMSS) 2015. Those responses indicate that Australian students are, on average, less engaged with mathematics and science than their international counterparts; with greater levels of disengagement exhibited in high school (year 8), compared to primary school (year 4).<sup>44</sup>

**Figure 5: Students (%) who do not like learning mathematics and science**

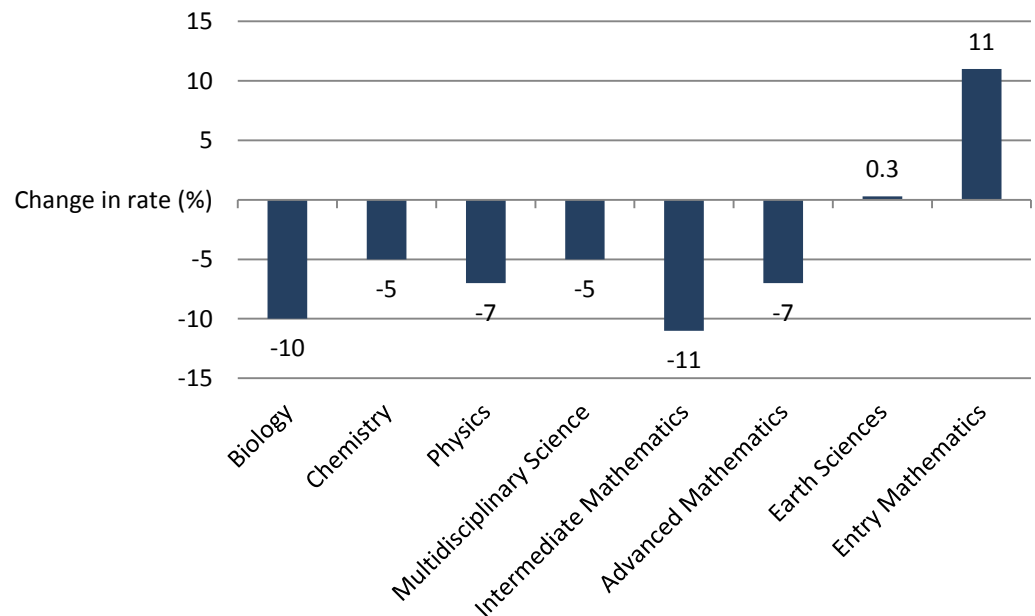


Source: TIMSS 2015 International Results in *Mathematics* and *Science*

## 5.2 Participation

Across Australia, there has been a decline in STEM participation in the later years of schooling, when STEM subjects become non-compulsory.<sup>45</sup> As depicted in Figure 6, after collecting raw enrolment data across Australian from 1992 to 2012, academics John Kennedy, Terry Lyons and Frances Quinn found that, while “[t]he total number of students in Year 12 increased by around 16% from 1992 to 2012 ... the participation rates for most Science and Mathematics subjects, as a proportion of the total Year 12 cohort, fell”.<sup>46</sup>

**Figure 6: Change in STEM participation rates (%), 1992 and 2012, Australia**



Source: Kennedy J, Lyons T and Quinn F, [The Continuing Decline of Science and Mathematics Enrolments in Australian High Schools](#), *Teaching Science*, 2014, 60(2), p 34.

Similarly, after analysing Mathematics enrolments in NSW from 2001 to 2015, the Centre for Education Statistics and Evaluation (CESE) reported a downwards shift from HSC Mathematics to HSC General Mathematics:

In New South Wales (NSW), overall enrolments in mathematics in the Higher School Certificate (HSC) have increased by seven per cent from 2001 to 2015. However, enrolments in the HSC Mathematics course, an intermediate mathematics course that includes calculus, decreased by 4,453 enrolments over this period ... This reflects a drop from 39 per cent of all mathematics enrolments in the HSC in 2001 to 29 per cent in 2015. At the same time, enrolments in the HSC General Mathematics course ... have increased by nine per cent since 2001.<sup>47</sup>

The CESE report suggests that this downwards shift may, in part, be due to a scaling advantage in favour of the HSC General Mathematics course over the HSC Mathematics course; and/or a perception that the HSC General Mathematics course requires a lesser workload than the HSC Mathematics course.<sup>48</sup>

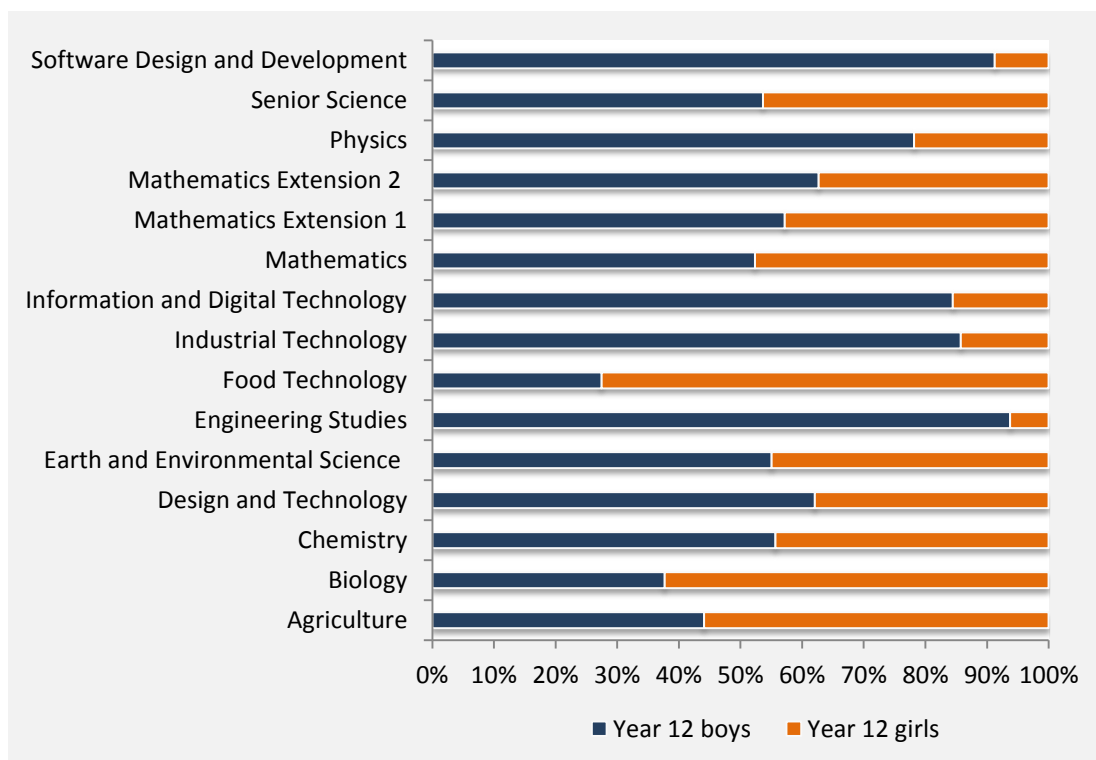
In addition to the overall decline in STEM participation rates, STEM participation in the senior years of high schools is subject to a gender gap in favour of boys.<sup>49</sup> For instance, in NSW government schools in 2016,



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there was a total of 53,279 course enrolments by Year 12 students for the 15 STEM subjects set out in Figure 7. Of those 53,279 enrolments, 30,550 (57%) were boys and 22,729 (43%) were girls.

**Figure 7: Year 12 enrolments, 15 STEM courses, NSW government schools, 2016**



Source: Centre for Education Statistics & Evaluation, *Schools and Students: 2016 Statistical Bulletin*, 2017, Table 22

### 5.3 Performance

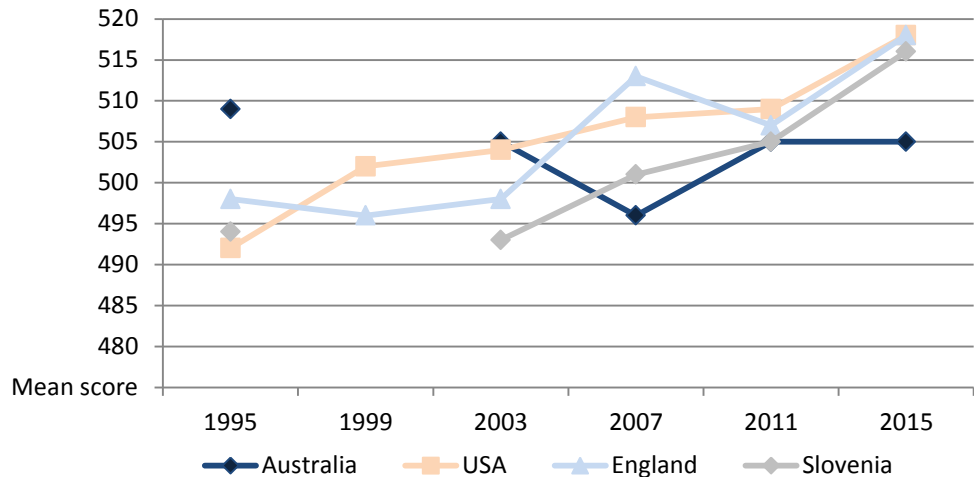
The performance of Australian and NSW school students in mathematics and science is outlined using data from the Trends in International Mathematics and Science Study (TIMSS), the Programme for International Student Assessment (PISA) and the National Assessment Program—Literacy and Numeracy (NAPLAN).<sup>50</sup> An overview of each assessment tool is presented in Table 3.

Table 3: Three measures of Mathematics and Science performance			
	TIMSS	PISA	NAPLAN
<b>Scope</b>	International	International	National
<b>Date</b>	1995, 2003, 2007, 2011, 2015	2000, 2003, 2006, 2009, 2012, 2015	Mathematics: Yearly from 2008 Science: 2003, 2006, 2009, 2012 and 2015
<b>Students</b>	Sample of Year 4 and 8 students. <sup>51</sup>	Sample of students aged between 15.3 and 16.2 years. <sup>52</sup>	Science: sample of Year 6 Students <sup>53</sup> Mathematics: All Year 3, 5, 7 and 9 students. Year 9 data is used in this e-brief, as it most closely matches the data from TIMSS and PISA in terms of student age.

### 5.3.1 Mathematics performance

**TIMSS (Year 8):** As set out in Figure 8, between 1995 and 2015, Australia’s Year 8 TIMSS mathematics scores have declined in absolute terms and relative to such countries as the USA, England and Slovenia.<sup>54</sup>

**Figure 8: Australia’s TIMSS Year 8 mathematics scores**



Source: Thomson S, et al, *TIMSS 2015, A first look at Australia’s results*, 2016, ACER, p 29

As set out in Table 4, with the exception of the Northern Territory, there was no statistically significant difference between NSW’s 2015 Year 8 mathematics score and that of other Australian jurisdictions.

**Table 4: TIMSS 2015 mean scores by jurisdiction, Year 8 mathematics**

ACT	NT	NSW	QLD	SA	TAS	VIC	WA
516	452	503	498	498	493	516	508

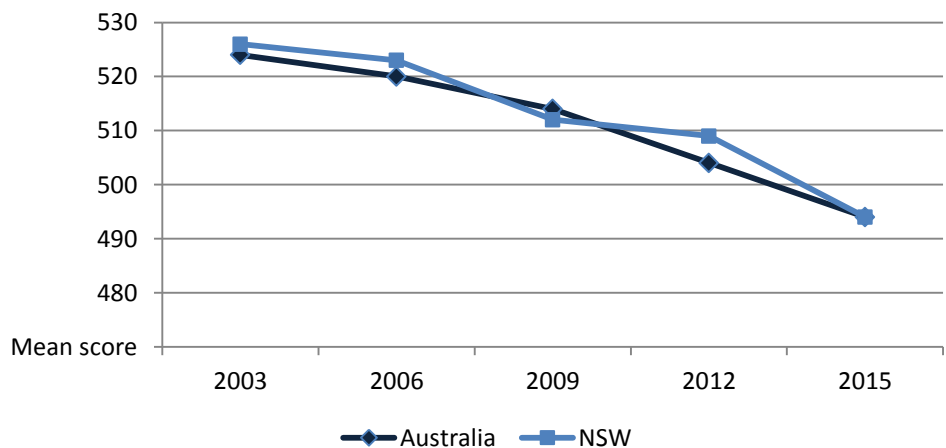
Mean score lower than NSW mean score to a statistically significant degree.

Source: Thomson S, et al, *TIMSS 2015, A first look at Australia’s results*, 2016, ACER, p 33

There was also no statistically significant difference between the mean scores of NSW Year 8 male (506) and female (499) students.<sup>55</sup>

**PISA:** As set out Figure 9, between 2003 and 2015, there was a statistically significant decline in Australia’s and NSW’s mathematics scores.

**Figure 9: PISA mathematics scores: Australia and NSW**



Source: Thomson S, et al, *PISA 2015: A first look at Australia’s results*, 2016, ACER, p 21 and 42

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The PISA 2015 mathematics scores for each jurisdiction and the OECD are detailed in Table 5. With the exception of the Australian Capital Territory, Northern Territory and Tasmania, there was no statistically significant difference between NSW's score and that of other jurisdictions.<sup>56</sup>

**Table 5: PISA mean scores, by jurisdiction, students 15.3–16.2 yrs, mathematics**

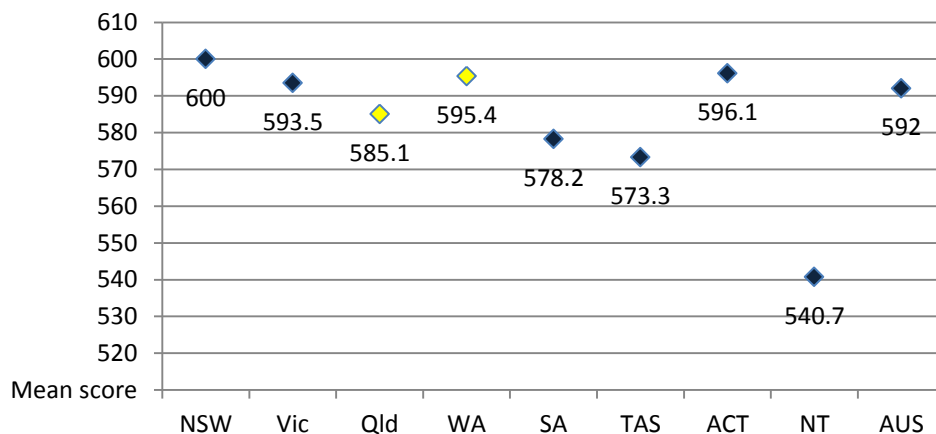
ACT	NT	NSW	QLD	SA	TAS	VIC	WA	OECD
505	478	494	486	489	469	499	504	490

Mean score **higher** or **lower** than NSW mean score to a statistically significant degree.  
Source: Thomson S, et al, *PISA 2015: A first look at Australia's results*, 2016, ACER, p 34

There was also no statistically significant difference between the mean score of NSW male (496) and female (492) students.<sup>57</sup>

**NAPLAN (Year 9):** As set out in Figure 10, based on the 2017 Preliminary results, NSW was the top-ranked State in Year 9 numeracy.<sup>58</sup> There was no statistically significant difference between NSW's 2017 preliminary result (600) and its 2008 final result (591.4).

**Figure 10: Year 9 2017 NAPLAN numeracy scores**

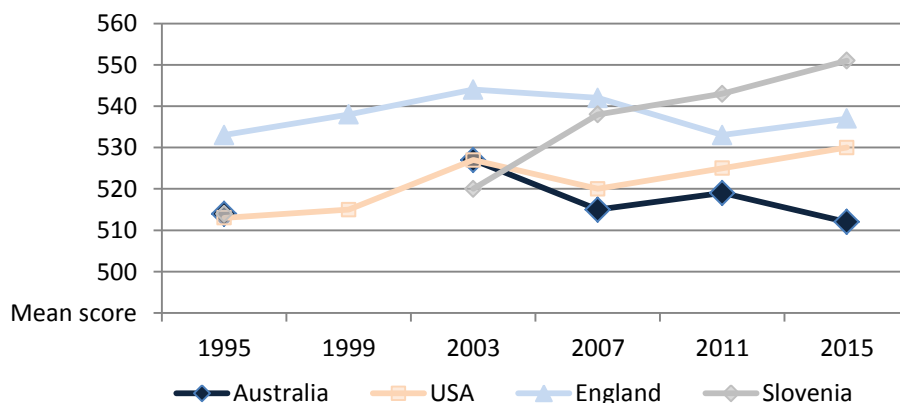


Yellow indicates score has increased to a statistically significant degree since 2008.  
Source: *National Assessment Program, 2017 Preliminary Results*, ACARA

### 5.3.2 Science performance

**TIMSS (Year 8):** Australia's Year 8 science scores are set out in Figure 11:

**Figure 11: TIMSS Year 8 science scores**



Source: Thomson S, et al, *TIMSS 2015, A first look at Australia's results*, 2016, ACER, p 67

Figure 11 reveals that, between 1995 and 2015, Australia’s Year 8 TIMSS scores declined in absolute terms (from 514 to 512) and relative to such countries as England, the United States and Slovenia.<sup>59</sup>

As set out in Table 6, with the exception of the Australian Capital Territory and the Northern Territory, there was no statistically significant difference between NSW’s mean Year 8 Science score and that of other jurisdictions

**Table 6: TIMSS 2015 mean scores by jurisdiction, Year 8 Science**

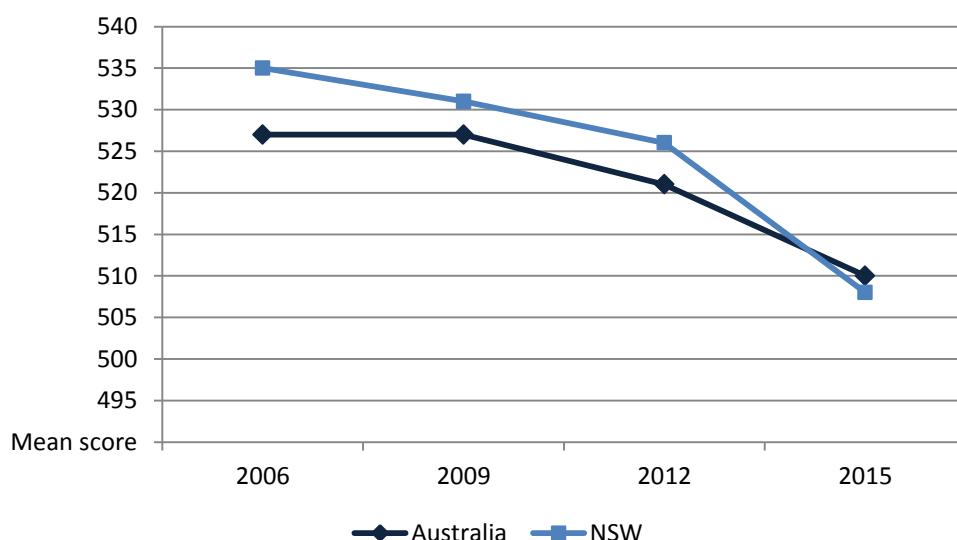
ACT	NT	NSW	QLD	SA	TAS	VIC	WA
528	463	511	507	507	503	518	518

Mean score higher or lower than NSW mean score to a statistically significant degree.  
 Source: Thomson S, et al, *TIMSS 2015, A first look at Australia’s results*, 2016 ACER, p 71

There was no statistically significant difference between the mean scores of NSW male (517) and female (505) students.<sup>60</sup>

**PISA:** As set out in Figure 12, between 2006 and 2015 there was a statistically significant decline in Australia’s PISA science scores.<sup>61</sup>

**Figure 12: PISA science scores: Australia and NSW**



Source: Thomson S, et al, *PISA 2015: A first look at Australia’s results*, 2016, ACER, p 11 and 36.

The PISA 2015 Science scores for each jurisdiction and the OECD are detailed in Table 7. There was a statistically significant difference between NSW’s score and that of the Australian Capital Territory, Northern Territory, Tasmania, Western Australia and the OECD.<sup>62</sup>

**Table 7: PISA mean scores, by jurisdiction, students 15.3–16.2 years, science**

ACT	NT	NSW	QLD	SA	TAS	VIC	WA	OECD
527	489	508	507	508	483	513	521	493

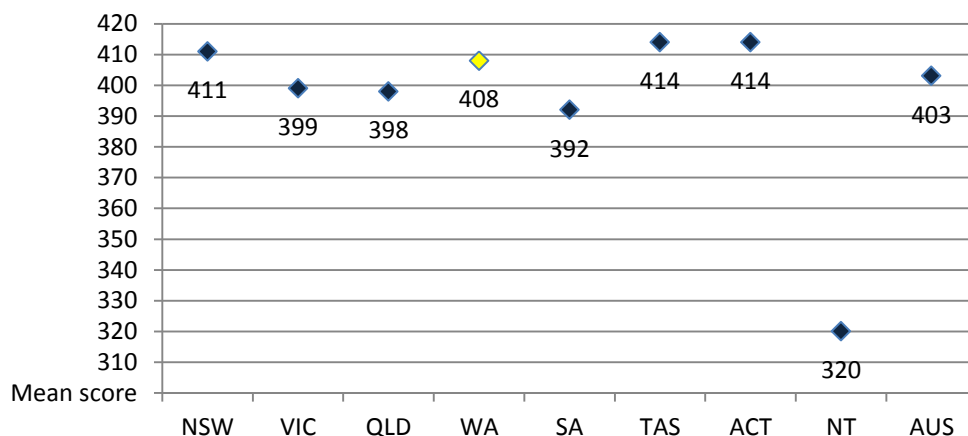
Mean score higher or lower than NSW mean score to a statistically significant degree.  
 Source: Thomson S, et al, *PISA 2015: A first look at Australia’s results*, 2016, ACER, p 31

The 2015 scores of NSW male and female students were identical (508).<sup>63</sup>

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**Year 6 NAPLAN:** As set out in Figure 13, NSW's 2015 science NAPLAN score was the third-highest of all jurisdictions.<sup>64</sup> NSW's 2015 NAPLAN science score of 411 was identical to its 2006 score.<sup>65</sup>

**Figure 13: Year 6 2015 NAPLAN science scores**



Yellow indicates score has increased to a statistically significant degree since 2006.

Source: [National Assessment Program—Science Literacy 2015](#), 2017, ACARA, p 23

## 6. National policy

### 6.1 National Science and Innovation Agenda and National Science Statement 2017

The aim of the [National Innovation and Science Agenda](#) and [National Science Statement 2017](#) are to encourage Australians to “embrace new ideas in innovation and science, and harness new sources of growth” in order to “deliver the next age of economic prosperity”.<sup>66</sup> Their initiatives span the school, university, industry and government sectors. The following two initiatives focus on enhancing STEM outcomes in primary and secondary schools.

**Inspiring all students in STEM:** Under the [Inspiring all Australians in Science, Technology, Engineering and Mathematics](#) component of the [National Innovation and Science Agenda](#), the Commonwealth Government allocated \$48 million over four years to establish and support a range of Science Prizes, grants, competitions, exhibitions, digital resources<sup>67</sup> and industry partnerships; as well as dedicated “maker spaces” in schools, “where students can apply their STEM knowledge, develop entrepreneurial skills, and gain experience in working with emerging and advancing technologies”.<sup>68</sup>

**Embracing the digital age:** Under the [Embracing the Digital Age](#) component of the [National Innovation and Science Agenda](#), the Commonwealth Government allocated \$51 million over four years to support teachers to implement the [Australian Curriculum: Digital technologies](#); establish Information Computer Technology (ICT) summer schools and competitions; create links between schools, scientists and ICT professionals; and provide Digital Literacy School Grants.<sup>69</sup>

## 6.2 National STEM school education policy

On 11 December 2015 Australian Education Ministers endorsed the [National STEM School Education Strategy 2016–2026](#) (the National Strategy). The National Strategy seeks to promote the twin goals of ensuring that:<sup>70</sup>

1. All students finish school with strong foundational knowledge in STEM.
2. More students are inspired to enrol in challenging STEM subjects in the senior years of high school.

These twin goals are to be achieved through the following five broad Areas for National Action set out in Table 8:<sup>71</sup>

Table 8: National STEM School Education Strategy 2016–2026
Areas for National Action
1. Increase student STEM ability, engagement, participation and aspiration.
2. Increase teacher capacity and STEM teaching quality.
3. Support STEM education opportunities within school systems.
4. Facilitate partnerships with tertiary education providers, business and industry
5. Build a strong evidence base.
Example of initiative under each Area for National Action
1. Establish a minimum level of numeracy attainment for all students to demonstrate before leaving school.
2. Lift the quality of initial teacher education, including through mandatory content requirements in mathematics and science, and a literacy and numeracy test for initial teacher education students.
3. Enhance the Year 6 NAPLAN Science assessment (in line with the yearly assessment of every child that occurs for numeracy).
4. Establish <a href="#">STEM Partnership Forums</a> to facilitate partnerships between schools, industry and the tertiary education sector.
5. Develop national reports to track change in STEM outcomes.

## 7. NSW policy

Unlike [Queensland](#),<sup>72</sup> [South Australia](#)<sup>73</sup> and [Victoria](#),<sup>74</sup> NSW does not have a stand-alone STEM school education policy. Nevertheless, as discussed below (at 7.1–7.7), NSW has taken a leading role in introducing reforms designed to improve both general and STEM education outcomes.<sup>75</sup>

### 7.1 NSW Innovation Strategy

Under the [NSW Innovation Strategy](#) the NSW Government aims to collaborate with industry and education providers in order to encourage greater student participation in university and VET level STEM education.<sup>76</sup> Demonstrating the potential benefits of such collaboration, on 11 May 2016 Deputy Premier John Barilaro announced that industry partners will provide a range of career development opportunities to 550 VET STEM students who qualified for a \$1,000 [Jobs of Tomorrow Scholarship](#).<sup>77</sup>

### 7.2 New and upgraded STEM school infrastructure

NSW's first STEM school is scheduled to open in 2019 at Sydney Science Park, a development planned for Londonderry in Western Sydney.<sup>78</sup> The NSW Government has also recently announced a \$46 million upgrade to wireless connectivity to more than 900 regional and remote NSW schools;<sup>79</sup> and a Science Lab Upgrade Program with an estimated total cost of \$21.3 million.<sup>80</sup>

### 7.3 STEM education resources

**STEM Action School mentoring program:** The NSW Department of Education has designated seven existing NSW public schools as STEM Action Schools:

Each Action School has staff with individual strengths and particular expertise. A goal of this program is to facilitate these experienced staff to lead a community of practice in the teaching of STEM across NSW ... NSW Public Schools are able to collaborate with STEM Action Schools and receive mentoring through an application process.<sup>81</sup>

**On-line STEM resources:** The NSW Department of Education provides access to a variety of online [STEM resources](#) and a [Project-Based Learning Toolkit](#).<sup>82</sup> The NSW Education Standards Authority also provides [advice](#) for teachers on integrating STEM across the curriculum and access to sample [STEM units of work](#) and [STEM activities](#).

### 7.4 Introduction of HSC minimum standards

On 19 July 2016, former NSW Education Minister Adrian Piccoli announced that “[f]rom 2020, students will need to demonstrate they have met a minimum standard in both literacy and numeracy to receive the HSC.”<sup>83</sup> Further, “Year 9 students will have their first opportunity to meet this new standard by achieving minimum band 8 results when they sit NAPLAN”.<sup>84</sup>

NSW's 2017 NAPLAN preliminary results reveal:

68 per cent of NSW Year 9 students, or 61,015, received at least one test result in band 8 or above, 52 per cent (46,481) received at least two test results at band 8 or above and 32 per cent (28,403) attained band 8 or above in all three.<sup>85</sup>

In direct response to a protest outside NSW Parliament House, former Education Minister Adrian Piccoli defended the introduction of the new minimum standards by stating that “the reform has seen a 50 per cent increase in the number of year 9 students achieving three band 8s or higher in NAPLAN compared to last year.”<sup>86</sup>

NSW Education Minister Rob Stokes has sought to allay concerns about the introduction of the new HSC minimum standards:

One thing that needs to be said at the outset – loud and clear – as NSW students are this week digesting their results, is that no student will be prevented from achieving their HSC on the basis of their Year 9 NAPLAN test results.

Yes, the NSW government has recently introduced a minimum standard of numeracy and literacy for the HSC, but students will have multiple opportunities to meet this standard.

A minimum standard of numeracy and literacy should not be controversial. Although the HSC is not a "pass/fail" exercise, we should not devalue it to the point where we are handing out a certificate to individuals who lack basic numeracy and literacy skills.

Parents should demand, and universities and future employers should expect, that an award of an HSC signifies, at the bare minimum, a Year 12 graduate is functionally numerate and literate.<sup>87</sup>

Paradoxically, while the new HSC minimum standards strengthen the academic rigour of the HSC, students who do not qualify for the HSC due to not meeting the new minimum standards are still eligible to receive an Australian Tertiary Admission Rank (ATAR) and enrol in a university degree.<sup>88</sup> That position reflects the current policy of the Universities Admission Centre.<sup>89</sup> The new HSC minimum standards also do not affect entry into many VET STEM courses; as entry into VET courses is often not dependent on attaining the HSC.<sup>90</sup> Concerns have been raised, however, that "weaker students at the lower end of the academic spectrum ... may now have to leave at the end of 12 years without a credential to prove they stayed the distance".<sup>91</sup>

### 7.5 Teaching standards

A core feature of NSW's efforts to improve school outcomes has been to raise teaching standards. The underlying rationale of such an approach was stated by former Education Minister Adrian Piccoli in a paper presented to the 2014 Education World Forum:

The quality of the teacher is the most important in-school influence on student performance. Research shows that the difference between good and poor teachers can amount to two years in student achievement, so raising teacher quality is the starting point for changing the way education is delivered across all schools.<sup>92</sup>

This approach is of particular importance to STEM education, as "an individual's knowledge and academic background in STEM is strongly linked to their capacity to teach it".<sup>93</sup>

**Increased teacher education requirements:** In NSW, from 2016, students seeking to enrol in teacher education courses are required to achieve at least three band 5 HSC results (80% or higher), including one in English.<sup>94</sup> Students must also pass a numeracy and literacy assessment before being eligible for provisional accreditation as a teacher.<sup>95</sup>

**Encouraging student teachers to specialise in STEM:** At the primary school level, teachers tend to be trained as generalists and required to teach a broad range of subjects.<sup>96</sup> This has led to graduates reporting a lack of capacity to teach STEM, with similar concerns expressed by principals and teacher educators.<sup>97</sup> In an effort to address this issue, on 9 May 2016 the NSW Government announced that teaching students can become STEM specialists by electing to study additional mathematics and science courses.<sup>98</sup>

**Encouraging existing teachers to retrain in STEM:** At the high school level, concerns have been raised that the quality of STEM education is being diminished by "out-of-field" teaching, where STEM subjects are taught by teachers without STEM qualifications.<sup>99</sup> The scope for out-of-field



teaching to undermine STEM education outcomes becomes readily apparent given that:

Around 20 per cent of secondary maths and science teachers across all sectors (government, independent and Catholic) are teaching 'out of field' – i.e. they are not qualified to teach the subject. TIMSS 2011 data show that the proportion of schools that have difficulty filling Year 8 maths and science teaching positions was about double the international average.<sup>100</sup>

In an effort to address this issue, on 20 February 2015 the NSW Government announced that it will aim to re-train up to 320 existing public school teachers as specialists in mathematics and science by offering scholarships, study leave and guaranteed future employment.<sup>101</sup>

### 7.6 Literacy and numeracy programs

In 2012 the NSW Government announced a \$261 million *State Literacy and Numeracy Action Plan* designed to provide early, evidence-based intervention to students in Kindergarten to Year 2 whose literacy and numeracy development indicated they required additional support.<sup>102</sup> The *Literacy and Numeracy Strategy 2017–2020* provides an additional \$340 million in order to continue the focus on early intervention and support.<sup>103</sup> Additionally, the *Bump it Up* strategy provides targeted intervention at 137 primary and secondary schools that have a high proportion of their students performing in the middle two NAPLAN bands.<sup>104</sup>

### 7.7 Curriculum

In the policy discussions concerning how best to improve STEM outcomes, a central concern is that key STEM concepts and skills are not being effectively taught and learned because the school curriculum is overcrowded; both in terms of the content of each subject and the overall number of subjects.<sup>105</sup> Alex Greenwich MP has argued that curriculum overcrowding will limit the extent to which NSW can grow its digital economy.<sup>106</sup> In this context, it is particularly noteworthy that in NSW primary schools, only 6-10% of teaching time (approximately 1.5 to 2.5 hours per week) is devoted to Science and Technology.<sup>107</sup>

In response to such concerns, the NSW Education Standards Authority (NESA) is in the process of wide-ranging curriculum reform designed to “reduce unnecessary breadth” and foster “depth and mastery” of key concepts.<sup>108</sup> The reforms include strengthening mathematics outcomes by creating a common marking scale to “discourage bright students from studying lower-level maths in order to boost their marks”.<sup>109</sup> Science outcomes are sought to be strengthened through the introduction of a new Science Extension course that can be studied in addition to existing science courses.<sup>110</sup> The new Science Extension course provides high-performing students with the opportunity to study with research organisations and universities, and publish their own scientific research.<sup>111</sup>

## 8. Conclusion

The STEM fields are widely recognised as being crucial to the economic prosperity and wellbeing of Australia and its people. However, since 1995, Australia's STEM school performance has generally declined; both in absolute terms and relative to other comparable nations. A number of

reforms have been introduced at a national and State level to redress that situation. Reforms introduced in NSW include strengthening teaching standards, introducing minimum HSC standards and redesigning aspects of the curriculum. Whether these reforms are successful in improving STEM outcomes will be closely evaluated.

Many issues remain concerning the scope of the term STEM; although the renewed emphasis on STEM school education is essentially a catchcry intended to bolster declining outcomes, rather than any attempt to undermine the ideal of a comprehensive education.

Ultimately, STEM school education is not a panacea. For Australia to continue to build and benefit from its STEM capacity, robust VET and university sectors are crucial; as is research and innovation across the public and private sectors. Targeted matching of students to specific occupations facing STEM skills shortages is also required. Only through such concerted efforts can Australia prosper from being the “clever country”.

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<sup>1</sup> See, for instance: Office of the Chief Scientist, [Science, Technology, Engineering and Mathematics: Australia's Future](#), 2014, p 6–7; The Australian Industry Group, [Progressing STEM Skills in Australia](#), 2015, p 8–9; Price Waterhouse Coopers, [Future-proofing Australia's workforce by growing skills in science, technology, engineering and maths \(STEM\): A smart move](#), 2015, p 14 and 17; West M, [STEM Education and the Workplace](#), Office of the Chief Scientist, Occasional Paper Series 4, 2012; and Marginson S et al, [Securing Australia's Future: STEM Country Comparisons](#), Australian Council of Learned Academies, 2013, Ch 3 and 4.

<sup>2</sup> See: Commonwealth Government, [National Innovation and Science Agenda Report](#), 7 December 2015.

<sup>3</sup> Queensland Department of Education and Training, [A Strategy for STEM in Queensland State Schools](#), 2016.

<sup>4</sup> Close S, [New STEM Strategy for SA schools](#), Media Release, 4 November 2016.

<sup>5</sup> Victorian Department of Education and Training, [VicSTEM: STEM in the Education State](#), 2016.

<sup>6</sup> Turnbull M, Birmingham S, Pyne C, [STEM head start for 350,00 pre-schoolers](#), Media Release, 8 February 2016. See also, Birmingham S, [Science skills key in literacy, numeracy push](#), Media Release, 3 September 2017.

<sup>7</sup> Marginson S, et al, [Securing Australia's Future: STEM Country Comparisons](#), Australian Council of Learned Academies, 2013, p 30.

<sup>8</sup> [National STEM School Education Strategy 2016–2026](#), COAG Education Council, p 5.

<sup>9</sup> A Kaspura, [Engineers Make Things Happen: The need for an engineering pipeline strategy](#), 2017, Engineers Australia, p 15 and G Siekmann, [What is STEM? The Need for unpacking its definitions and applications](#), National Centre for Vocational Education Research (NCVER), 2016, p 10.

<sup>10</sup> Section 3(1)(a)(i) of the *Australian Education Act 2013* (Cth).

<sup>11</sup> Marginson S, et al, [Securing Australia's Future: STEM Country comparisons](#), Australian Council of Learned Academies, 2013, p 58.

<sup>12</sup> COAG Education Council, [National STEM School Education Strategy 2016–2026](#), p 4.

<sup>13</sup> Office of the Chief Scientist, [Australia's STEM Workforce](#), 2016, p 24. In this report STEM was defined as excluding qualifications in health.

<sup>14</sup> Australian Bureau of Statistics, [Perspectives on Education and Training: Australians with qualifications in science, technology, engineering and mathematics \(STEM\), 2010–2011 \(4250.0.55.005\)](#), 2014.

<sup>15</sup> Ibid. The definition of STEM used in the ABS report excluded jobs in the health field. See also the related media release: Australian Bureau of Statistics, [Qualifications paying off in science, technology, engineering and maths](#), 24 February 2014.

<sup>16</sup> Jobs for NSW, [Jobs for the Future: Adding 1 million rewarding jobs in NSW by 2036](#), 2016, p 32.

<sup>17</sup> Office of the Chief Scientist, [Australia's STEM Workforce](#), 2016, p 30–31.

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- <sup>18</sup> Ibid, p 3.
- <sup>19</sup> Price Waterhouse Coopers: [Future-proofing Australia's workforce by growing skills in science, technology, engineering and maths \(STEM\): A smart move](#), 2015, p 4.
- <sup>20</sup> Office of the Chief Scientist, [Science, Technology, Engineering and Mathematics: Australia's Future](#), 2014, p 7.
- <sup>21</sup> Commonwealth Government, [National Innovation and Science Agenda Report](#), 7 December 2015.
- <sup>22</sup> Office of the Chief Scientist, [Science, Technology, Engineering and Mathematics: Australia's Future](#), 2014, p 7.
- <sup>23</sup> Ibid, p 7.
- <sup>24</sup> Marginson S, et al, [Securing Australia's Future: STEM Country comparisons](#), Australian Council of Learned Academies, 2013, p 68. See also: Atkinson R and Mayo M, [Refuelling the US Innovation Economy: Fresh Approaches to Science, Technology, Engineering and Mathematics \(STEM\) Education](#), The Information Technology and Innovation Foundation, 2010, p 21.
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- <sup>29</sup> *Education Act 1990*, s 6(1A)(b).
- <sup>30</sup> COAG Education Council, [National STEM School Education Strategy, 2016-2026](#), 2015, p 5.
- <sup>31</sup> *Education Act 1990*, s 9.
- <sup>32</sup> NSW Education Standards Authority, [The HSC in a Nutshell](#), 2015.
- <sup>33</sup> Marginson S, et al, [Securing Australia's Future: STEM Country comparisons](#), Australian Council of Learned Academies, 2013, p 54 and Ch 11. See also: Angus C, [Future workforce trends in NSW: Emerging Technologies and their potential impact](#), NSW Parliamentary Research Service, 2015, p 48–49.
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- <sup>36</sup> Office of the Chief Scientist, [Business partners with schools on Science, Technology, Engineering and Mathematics](#), 18 May 2017.
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- <sup>42</sup> Commonwealth Government, [National Innovation and Science Agenda Report](#), 7 December 2015. See also: Commonwealth Government, [Supporting innovation through visas](#), no date [website—accessed 18 September 2017].
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- <sup>44</sup> See: [TIMS 2015 International Results in Mathematics: Student Engagement and Attitudes](#) [website — accessed 18 September 2017] and [TIMS 2015 International Results in Science: Student Engagement and Attitudes](#) [website — accessed 18 September 2017].

- <sup>45</sup> See: Kennedy J, Lyons T and Quinn T, [The Continuing Decline of Science and Mathematics Enrolments in Australian High Schools](#), *Teaching Science*, 2014, 60(2), p 34; Pitt D, [On the scaling of NSW HSC marks in mathematics and encouraging higher participation in calculus-based courses](#), *Australian Journal of Education*, 2015, 59(1) p 65–81; and Wilson R and Mack J, [Declines in High School Mathematics and Science Participation: Evidence of Students' and Future Teachers' Disengagement with Maths](#), *International Journal of Innovation in Science and Mathematics Education*, 2014, 22(7), p 35–48.
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- <sup>48</sup> *Ibid*, p 17.
- <sup>49</sup> NSW Ministry of Health, [Education and Learning: Women in NSW Report Series 2016](#), 2016, p 7–8. See also: Office of Chief Scientist, [Busting the myths about women in STEM](#), Media Release, 11 November 2016.
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- <sup>52</sup> Thomson S, et al, [PISA 2015: A first look at Australia's results](#), 2016, p XX. In statistically weighted terms, 256,330 students from across Australia (including 80,200 from NSW) participated in PISA 2015. In terms of the sample size, n = 14,530 Australian and 3,373 NSW students.
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- <sup>56</sup> Thomson S, et al, [PISA 2015: A first look at Australia's results](#), Australian Council for Educational Research, 2016, p 34.
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- <sup>62</sup> *Ibid*, p 31.
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- <sup>65</sup> *Ibid*, p 23. ACARA chose the 2006 test as the statistical baseline because it covered more remote schools and questions that catered to a greater range of student ability.
- <sup>66</sup> Commonwealth Government, [National Innovation and Science Agenda](#), no date [website — accessed 18 September 2017].
- <sup>67</sup> See, for example, [STARportal](#), which was launched by the Office of the Chief Scientist on 16 August 2017: Office of the Chief Scientist, [Expanding STEM Options for all Australian Students](#), Media Release, 16 August 2017.
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- <sup>69</sup> National Innovation and Science Agenda, [Embracing the Digital Age](#), no date [website — accessed 18 September 2017].

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- <sup>70</sup> COAG Education Council, [National STEM School Education Strategy, 2016-2026](#), 2015, p 5.
- <sup>71</sup> Ibid, p 7–10.
- <sup>72</sup> Queensland Department of Education and Training, [A Strategy for STEM in Queensland State Schools](#), , 2016.
- <sup>73</sup> Close S, [New STEM Strategy for SA schools](#), Media Release, 4 November 2016.
- <sup>74</sup> Victorian Department of Education and Training, [VicSTEM: STEM in the Education State](#), 2016.
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- <sup>76</sup> NSW Government, [Bringing Big Ideas to Life: NSW Innovation Strategy](#), 2016, p 11.
- <sup>77</sup> Barilaro J, [Industry Support for Vocational STEM Scholarships for the Jobs of Tomorrow](#), Media Release, 11 May 2016.
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- <sup>79</sup> Mitchell S, [Connecting Country Schools](#), *NSW Hansard*, 22 June 2017, p 48 (proof).
- <sup>80</sup> NSW Budget 2017–18, [Budget Paper No 2, Infrastructure Statement](#), p 5–9.
- <sup>81</sup> The seven STEM Action Schools are: East Hills Girls Technology High School, Hastings Secondary College, Macarthur Girls High School, Maitland Grossmann High School, Narara Valley High School, Riverside Girls High School, The Canobolas Rural Technology High School: NSW Department of Education, [STEM Action School Mentoring Program](#), no date, p 3.
- <sup>82</sup> NSW Department of Education, [Stem Portal: Stage 3 STEM Projects and Stage 4 STEM Projects](#), no date [website—accessed 18 September 2017].
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