Appendix 2. STEM: Country Comparisons: International Comparisons of Science, Technology, Engineering and Mathematics (STEM) Education

Introduction

STEM is a central preoccupation of policy makers across the world. A robust capacity in science, technology, engineering and mathematics (STEM) is pivotal to increasing Australia's productivity.

Governments seek to lift the overall scientific literacy of their populations and to draw most, or all, students into senior secondary school studies in STEM. For most countries, initiatives targeted at student attitudes and identity were a significant part of the strategic mix. This included initiatives to increase awareness of the nature of STEM professions.

The ACOLA report, SAF02 *STEM: Country Comparisons: International Comparisons of Science, Technology, Engineering and Mathematics (STEM) Education* (http://acola.org.au/wp/project-2/) focuses on strategies, policies and programs used to enhance STEM at all levels of education and in the education/work interface. The interdisciplinary report examines solutions to the STEM skills shortage in comparable countries to determine which, if any, could be usefully applied in Australia to overcome similar shortages here.

The importance of STEM

The international push to enhance STEM is part of a broader objective to lift educational qualifications and increase the number of people capable in research, commercial innovation and responding to technological change.

Countries regard the STEM disciplines as essential for global economic positioning and social creativity. Nations with leading and dynamic economies tend to be those with the strongest performing education and/or research science systems.

Countries rarely have a shortage of STEM graduates. Periodically in Australia there is a lack of STEM graduates in disciplines such as engineering and computing. Currently there are challenges facing our research and development and innovation sectors, and there are some labour market shortages in STEM occupations, principally engineering.

Features of strong STEM countries

There are five distinguishing characteristics of countries strong in STEM:

1. School teachers are held in high esteem, are well paid and are rewarded for performance and professional development.
2. Unlike in Australia, STEM teachers are expected to be fully qualified in their discipline and to teach solely in that field.
3. The most successful countries have instituted active curriculum programs that make science and mathematics more engaging and practical.

4. Many of the successful countries have implemented innovative policies to lift STEM participation among formerly excluded groups, such as low-achieving and Indigenous students.
5. There are national STEM policy frameworks that support centrally driven and funded programs; world-class university courses; the recruitment of foreign science talent; and partnerships that link STEM activities in schools, vocational and higher education with industry, business and the professions. Frequently, there are agencies that have been specifically created to advance the national STEM agenda.

How does Australia rate?

The 2009 study by the Program for International Student Assessment ranked Australia as equal 7th of all nations in science and equal 13th in mathematics. The 2012 study ranked Australia 16th in science and 19th in mathematics.

The percentage of year 12 students enrolled in higher level STEM in Australia has been declining for decades. From 1992 to 2010 the proportion of year 12 students in biology fell from 35 to 24 per cent, and in physics from 21 to 14 per cent.

There was a lesser decline in mathematics, from 77 per cent to 72 per cent, but most students were enrolled in elementary mathematics subjects. Only 10 per cent participated in advanced mathematics at year 12 level. A growing proportion of high-achieving year 12 students, particularly girls, participate in no mathematics program at all.

Australia does not have enough mathematics and science teachers. There are shortages, especially in rural and remote communities. However, a larger problem is teaching 'out of field', such as in mathematics, where teachers take classes for which they have little, or even no, university training.

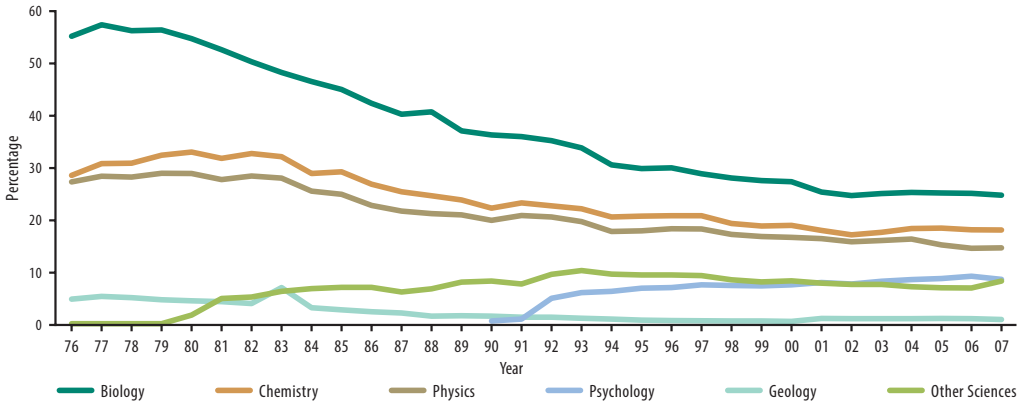
Australia is relatively strong in participation in the sciences at tertiary level, but weak in mathematics and engineering. Twenty-six per cent of PhDs awarded in 2008 were in science, with 14 per cent – a low figure by international standards – in engineering. But any growth in science and engineering has been among international students: the number of domestic students starting a PhD in Australia in science and engineering in 2010 was below the 2004 level. This was in sharp contrast with the rapid growth of STEM doctorates in many other countries.

Despite a plethora of government policies and reviews focused on education, science and innovation and the relatively recent emergence of the STEM agenda, Australia still needs to lift its performance in the foundation skills of literacy (reading and writing skills) and numeracy (arithmetic skills); in the enabling sciences (physics and chemistry); in general scientific literacy; and in mathematics.

International attitudes

Of 22 commissioned studies of educational policies and practices in relation to STEM around the world, most found that science and technology are valued by the public in the countries concerned and by parents of school students. There is a strong influence of families, and public attitudes, on STEM participation.

The negative correlation between student attitudes to STEM learning and country index of development highlights the challenge of engaging students with science-related subjects and STEM futures in Australia. That is, students in *developing* countries are more likely to say that they like school science better than most other subjects than those in *developed* countries.



Year 12 science participation as a percentage of the year 12 cohort in Australian schools, 1976 to 2007. (Source: Ainley J, Kos J, Nicholas M (2008) *Participation in Science, Mathematics and Technology in Australian Education*. Research Monograph no. 63, ACER, Melbourne)

Conclusion

It is in Australia's interests to inspire more students to learn STEM and to enter STEM-based careers, and to have more high-achieving students study science, mathematics and engineering.

Many countries have a more stringent approach to curriculum offerings than Australia, for example requiring the study of mathematics to year 11.

In order to encourage Australian students to consider choosing STEM subjects and associated career choices:

1. Mathematics and science experiences before the early middle years of schooling need to be positive and engaging.
2. Students should be made aware of the range of people and activities comprising STEM work in society.
3. Mathematics should possibly be made compulsory for everyone to the end of year 11 or even year 12.
4. Effective partnerships need to be fostered between civil and business organisations and education institutions that support innovation in school mathematics and science.
5. Australia would benefit from national coordination of approaches to improving participation in STEM.

Expert Working Group Members

Professor Simon Marginson FASSA (Chair)
Professor Russell Tytler (Deputy)
Professor Stephen Gaukroger FAHA
Mr David Hind FTSE
Professor Nalini Joshi FAA
Professor Geoff Prince
Professor Sue Richardson FASSA