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Science Achievement in Australia : Evidence from National and International Surveys.

Sue Thomson
ACER, sue.thomson@acer.edu.au

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Australian Council for Educational Research

Sue Thomson is a Principal Research Fellow at ACER. Dr Thomson is the National Research Coordinator for Australia in the Trends in International Mathematics and Science Study (TIMSS), which measures trends in mathematics and science achievement for students in grades 4 and 8, and as the National Project Manager for Australia for the OECD Programme for International Student Assessment (PISA), which examines reading, mathematical and scientific literacy of 15-year-old students.

Sue has worked on the Longitudinal Surveys of Australian Youth programme, and has managed the Australian component of Schools around the World, an international project examining assessment in science and mathematics, and Project Good Start, which examined children's numeracy in the transition from preschool to the first year of school.

Abstract

What can we say about science achievement in Australian schools? Does it really need a boost? Is science education in Australia engaging and motivating, or is the curriculum irrelevant and students disinterested? Are there particular issues for Indigenous students? Within the National Testing Program, Australia participates in two major international studies with a partial focus on science: the Trends in International Mathematics and Science Study (TIMSS), conducted with Year 4 and Year 8 students and managed by the International Association for the Evaluation of Educational Achievement (IEA); and the OECD Programme for International Student Assessment (PISA), conducted with 15-year-old students. In addition, the Longitudinal Surveys of Australian Youth (LSAY) program provides us with evidence about the outcomes of education, and the TIMSS Science Video Study provides us with a comparative view of the Australian science classroom and describes its practices. The presentation utilises data from these studies and examines what we know about science teaching in Australia, what students know and understand about science, whether they are interested in science, and whether they continue to study the sciences.

Introduction

The theme of this conference is 'Boosting science learning'. Before we can look at whether science learning needs a boost, however, we should look at the evidence about achievement, about whether students find science engaging and motivating, and whether there are particular issues for particular sub-groups of the population. This paper examines the evidence from Australia's participation in two major international studies that have a partial focus on science: the Trends in International Mathematics and Science Study (TIMSS), conducted with Year 4 and Year 8 students and managed by the International Association for the Evaluation of Educational Achievement (IEA); and the OECD Programme for International Student Assessment (PISA), conducted with 15-year-old students. Further evidence from the Longitudinal Surveys of Australian Youth (LSAY) program will be examined to ascertain students' participation in sciences at the post-compulsory level, and from the TIMSS Science Video Study to describe the practices in Australian science classrooms. The presentation utilises data from these studies and examines what we know about science teaching in Australia, what students know and understand about science, whether they are interested in science, and whether they continue to study the sciences.

What do we know about science teaching in Australia?

There are two sources of evidence about science teaching in Australia. Firstly, we have data from the teachers of the TIMSS students – not a random sample of teachers but the teachers of a sample of students whose class was chosen randomly. Secondly, we have the TIMSS Video Study, which was a highly intensive examination of Year 8 science teaching in five countries. In Australia, 87 schools participated and the teacher of the science class was filmed for one complete Year 8 science lesson.

The TIMSS survey focused on factors such as teachers' backgrounds, readiness to teach, participation in professional development, and teachers' perceptions about factors limiting instruction. A key element in what students have learned is the amount of time given to teaching science. At Year 4, students

in Australia spent about 5 per cent of their instructional time learning science, which is the third lowest proportion of all countries participating in TIMSS at this level and significantly less than the international average. The proportion of instructional time varied from 16 per cent for the Philippines to 3 and 4 per cent in the Netherlands and Norway. Australian students in Year 8 spent, on average, 13 per cent of their instructional time on learning science, which was similar to the international average and the instructional time spent in 'like' countries such as the USA, England and New Zealand.

Data from the TIMSS video study suggests that Year 8 science lessons focus in some way on high content standards and expectations for learning. Of course the definition of high content standards varies from country to country. In addition, the data suggested that a common content-focused pedagogical approach was used in all of the higher-achieving studies examined.

A number of other teacher characteristics from the TIMSS teacher questionnaires will be discussed along with their relationship with levels of achievement in science. Also examined will be the blueprint 'ideals for science education in Australia' as described in the TIMSS science video study, and their relationship with what was actually observed in the classrooms.

What science do students know and understand?

PISA

The OECD considered science to be so pervasive in modern life that it is important for the future citizens of a country to be scientifically 'literate'. The OECD defined scientific literacy as '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'. PISA was developed to monitor educational outcomes and, because of its cyclical nature, is able to monitor trends in performance over time. PISA allows us to make comparisons of achievement in scientific literacy across OECD (and other) countries. The focus of each cycle of PISA rotates through the three major domains – reading literacy (2000), mathematical literacy (2003) and scientific literacy, which has been the major domain examined in the recent data collection for PISA 2006. In each of the years 2000 and 2003, scientific literacy was examined as a minor domain, and when the data analysis for PISA 2006 is complete we will achieve a complete picture of scientific literacy in the final year of compulsory schooling.

From the PISA assessments to date we are able to group Australian students with countries such as the Netherlands, New Zealand, the Czech Republic, Hong Kong, China and Canada. These countries scored, on average, at a significantly lower level than Finland, Japan and Korea but significantly higher than the OECD average and higher than a group of countries including France, Germany and the USA. The average achievement level of Australian students remained the same since PISA 2000, and, as in PISA 2000, there were no gender differences in scientific literacy in Australia.

The average achievement level of Indigenous Australian students in scientific literacy was significantly lower than that of non-Indigenous students and significantly lower than the international average. These results were very similar to the results in PISA 2000.

TIMSS

The 2002 TIMSS assessment continues Australia's participation in international studies in science, extending back to the First International Science Study in 1970. The present study is the third combined mathematics and science study in which Australia has participated since 1994, and provides the opportunity to build a comprehensive picture of trends in, and patterns of, achievement in science at Year 4 and Year 8. TIMSS uses the curriculum as the major organising concept in considering how educational opportunities are provided to students and how students use these opportunities, and science is assessed in each cycle of the study. There are three content domains defined at Year 4: Life Science, Physical Science and Earth Science, and five domains defined at Year 8: Life Science, Chemistry, Physics, Earth Science and Environmental Science. As well as reporting overall science scores and scores in each of the defined domains, TIMSS also developed four international benchmarks, ranging from an advanced benchmark to a low benchmark.

At Year 4, Australian students scored significantly higher than the international average, statistically similar to that of students in countries such as the Russian Federation, the Netherlands, New Zealand, Belgium and Italy. This group scored at a significantly lower level than the high-performing countries – Singapore, Chinese Taipei, Japan, Hong Kong China, England, the USA and Latvia.

Australia's level of achievement at Year 4 is the same as it was in TIMSS 2002. Of the countries that participated in both TIMSS 1994 and TIMSS 2002, almost half had an average score in 2002 that was significantly higher than Australia's, compared to only one country in 1994.

The achievement of Indigenous students at Year 4 was about three-quarters of a standard deviation lower than that of non-Indigenous students, and was significantly lower than the international average. This indicates a relative worsening of the position of Indigenous students from TIMSS 1994.

At Year 8, Australia's score was again significantly higher than the international average. This score was statistically similar to the scores of students in the Netherlands, the USA, Sweden, Slovenia and New Zealand, but statistically lower than that of students in Singapore, Chinese Taipei, Korea, Hong Kong, Estonia, Japan, England and Hungary. Australian students' scores in science significantly increased from TIMSS 1994, as did those of several other 'like' countries.

The achievement of Indigenous students at Year 8 has significantly improved since TIMSS 1994 – in comparison, the performance of non-Indigenous students remained statistically the same.

Examining the percentage of students who attain the benchmarks in science is also informative. In Year 4 science, 9 per cent of Australian students reached the advanced international benchmark, a significant decline from the 13 per cent who attained this level in TIMSS 1994. Ninety-two per cent of Australian students achieved the 'low' international benchmark, which is similar to the proportion in TIMSS 1994; however, this low benchmark only states that children 'have some elementary knowledge of the earth, life, and physical sciences'. As a developed country, we should think about what an acceptable measure of scientific knowledge should be. The intermediate benchmark is that 'students can apply basic knowledge and understanding to practical situations in the sciences'. If this is a minimum standard, only three-quarters of our Year 4 students attained that standard.

A very similar picture can be painted for Year 8 students. Nine per cent of students attained the advanced international benchmark, a similar proportion to TIMSS 1994. The low benchmark is described at Year 8 level as 'students recognise some basic facts from the life and physical sciences'. Only 5 per cent of students were unable to attain this benchmark, compared to 11 per cent in 1994. The intermediate benchmark states that 'students can recognise and communicate basic scientific knowledge across a range of topics'. Around one-quarter of Year 8 students did not reach this benchmark; however, this was an improvement from the 31 per cent who failed to reach it in the TIMSS 1994 assessment.

In TIMSS 1994, there were gender differences for Australian students at Year 4 (males performed significantly better than females) but none at Year 8 level. Internationally, all significant gender differences at Year 4 and Year 8 were in favour of males. In TIMSS 2002, however, gender differences internationally were not consistently in favour of males. In a number of countries, there were large gender differences at both year levels in favour of females. In Australia, however, the gender equality seen in TIMSS 1994 had disappeared – males scored around one-fifth of a standard deviation (about 20 score points) higher than females.

At Year 4, few gender differences were evident in the attainment of benchmarks. At Year 8, twice the proportion of male than female students achieved the international benchmark, and slightly fewer males than females failed to achieve the low benchmark. Only 3 per cent of male Indigenous students attained the advanced international benchmark; no female Indigenous student attained this level. More than 60 per cent of Indigenous female students and 40 per cent of male Indigenous students did not achieve higher than the lowest benchmark.

Are students interested and confident in science?

Evidence about students' attitudes to science is currently gathered from the TIMSS studies. There are questions in PISA but they are set in the context of mathematics for the recent cycle. Students at both year levels were asked to report on their levels of self-confidence in science and whether they enjoy learning science, and Year 8 students were asked the level at which they value science and whether in the future they envisaged a job involving science.

Self-confidence

Australian students generally reported quite high levels of self-confidence, with 66 per cent of Year 4 students and 49 per cent of Year 8 students at the high level of the self-confidence index. In Australia and internationally there is a positive relationship between self-confidence and achievement; however, curiously most of the highest scoring countries had relatively low percentages of students with high levels of self-confidence.

At Year 4 there were no gender differences in self-confidence in science; however, at Year 8 a significantly higher proportion of males reported a high level, and a significantly higher proportion of females, reporting a low level of self-confidence.

Although at least two-thirds of all Indigenous students report having either a medium to high level of self-confidence in learning mathematics, there are still a large proportion

of Indigenous students (both male and female) who indicate low self-confidence in undertaking science study. Of the female Indigenous students, one-third report low self-confidence in learning science. For the male Indigenous students, this figure is closer to one-quarter.

Enjoyment of science

The degree to which students enjoy learning science has some association with science achievement, and it almost certainly has an association with engagement in science leading to continued studies in the area. Most (87%) Year 4 students agreed that they like science to some extent, falling to about two-thirds (67%) of Year 8 students. Australia was one of a small number of countries that showed a significant increase, at both year levels, in the proportion of students who agreed 'a lot' that they enjoyed learning science.

Valuing science

In Australia, the level of students' valuing of science is lower than the international average – only 36 per cent of Year 8 students placed a high value on learning science; however, the correlation between valuing science and achievement (0.26) is higher than the international average. There were significant gender differences evident, with 40 per cent of males and only 33 per cent of females placing a high value on learning science. Only 18 per cent of students were confident that they would like a job involving science, while a further 24 per cent were lukewarm about the idea.

Those Indigenous male students who indicate a high valuing of science performed at a level similar to the non-Indigenous national average. However, those Indigenous female students who report a similar high valuing of science still achieved scores significantly below that of the international and non-Indigenous national averages.

No relationship was found between self-confidence in learning science and science achievement for either male or female Indigenous students. However, the higher a male Indigenous student valued science, the more likely it was that they achieved at a level that was similar to the non-Indigenous national average for science achievement. Unfortunately, for the female Indigenous students, none of the examined attitude variables (self-confidence, enjoyment and value in learning mathematics or science) appeared to improve female mathematics and science achievement to a level similar to the non-Indigenous national average.

Educational aspirations

Australian students had somewhat lower educational aspirations on average than their international classmates. Internationally, 54 per cent of Year 8 students reported that they expected to complete university, compared to just 40 per cent of Australian students. Those who expected to finish university had substantially higher science achievement levels than those who did not.

Almost one-third of female Indigenous and one-quarter of male Indigenous students wish to complete TAFE; however, the number of Indigenous students who wish to continue with tertiary studies and complete a bachelor's degree is around half of the proportion of non-Indigenous students with similar aspirations.

Do students study science when it's not compulsory?

TIMSS and PISA have provided us with evidence about the achievements, attitudes and self-confidence of Australian students in a global context. This section of the paper looks at whether this translates into enrolments in science-related areas at the level of schooling when studying science is not compulsory. These data are derived from the *Longitudinal Surveys of Australian Youth* (LSAY), which tracks students from the middle years of secondary school until they are in their mid-twenties, and from its predecessor, the *Youth in Transition Survey* (YIT).

Of the Year 12 students who participated in the 2001 data collection for the 1998 cohort of LSAY, 55 per cent were studying one of the sciences. Almost four in ten students were studying at least one subject in the biological sciences area and about one-quarter were studying at least one subject in the physical sciences area.

Enrolments in chemistry and physics have declined in the period 1993–2001, from about 23 per cent to 18 per cent in chemistry and from to 17 per cent in physics. Enrolments in biology also decreased, from 32 per cent in 1993 to 25 per cent in 20 per cent in 2001.

So who is it that studies the sciences at this level? The data suggest two answers to this question, depending on whether it is biological sciences or physical sciences. Females were much more likely than males to be enrolled in biological sciences, males much more likely than females to be enrolled in the physical sciences. There seems to be a tendency for those in the highest achievement levels, and for those from higher socioeconomic backgrounds, to enrol in the physical sciences rather than in the biological sciences. The profile of those enrolled in the physical sciences is high achiever, male, parents from high socioeconomic background, high levels of parental occupation and education, and with a language background other than English. Further analysis found that students who had studied in the physical sciences area

were much more likely to go onto higher education (about 80% did so), while of those who had studied 'other sciences', around one-quarter did not participate in any further education or training, about 40 per cent went into higher education and the remaining third into some form of vocational education and training.

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