3

Decline in Enrolments in Enabling Sciences

3.1 The Committee inquired into:

- whether there has been a decline in university enrolments in the study of 'enabling sciences', namely, physics, chemistry and mathematics; and
- possible strategies to encourage greater participation in these disciplines.

Statistical data on participation trends in 'enabling sciences'

3.2 Two issues emerged in relation to tracking trends in participation rates in the enabling sciences at tertiary levels:

- the definition of an enabling science used to aggregate data; and
- the timeframe chosen to establish the trend in participation.

Aggregation of data

3.3 DEEWR provided data sets describing enabling science enrolments (see Table 3.1).[1] The Department suggested, that the decline in

1 DEEWR, *Supplementary Submission 1.2*, p. 5.

proportion of students participating in 'hard sciences' should be understood in the wider context of higher levels of participation in tertiary education overall and the increase and diversity in available courses.[2]

3.4 The data provided by DEEWR supports the contention that:

> the overall context … in enabling science enrolments is probably something pretty flat which wobbles up and down by a few percentage points.[3]

3.5 Some factors identified as contributing to fluctuations in participation rates included:

- movements in numbers of school leaver entrants to higher education;
- natural movements in population; and
- fluctuations in continuers.[4]

3.6 DEEWR provided further details on this matter:

> The number of Science, Engineering and Technology enrolments as a percentage of total domestic undergraduate enrolments has decreased by four percentage points [from] 2001 [to 2006]. This decline is mainly due to a significant decline in Information Technology enrolments, though there has also been a slight decline in the Natural and Physical Sciences.[5]

3.7 Dr John Ridd pointed to a number of the features of the official data sets that obscure the trends in 'hard sciences'. In relation to information provided in DEEWR's submission, Dr Ridd stated:

> it is important to note that the Department decided to use the disciplines listed in the Table as being the 'enabling' subjects. That was not the original definition proposed by the former Chief Scientist Batterham who defined 'enabling' as being hard maths, Physics and Chemistry … I cannot see Astronomy as being 'enabling' at all, and hence should not be included.[6]

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2 DEEWR, *Transcript of Evidence*, 6 June 2008, p. 2.

3 DEEWR, *Transcript of Evidence*, 6 June 2008, p. 3.

4 DEEWR, *Transcript of Evidence*, 6 June 2008, p. 2.

5 DEEWR, *Supplementary Submission* 1.1, p. 3.

6 Dr Ridd, *Submission 2*, p. 2.

Table 3.1 Enabling Science Enrolments

Domestic Undergraduate	2001	2002	2003	2004	2005	2006	2007	Change 01-07	Change 06-07
0101 Mathematical Sciences	2,215	2,347	2,316	2,393	2,282	2,177	2,024	-8.6%	-7.0%
0103 Physics and Astronomy	784	880	937	989	957	898	796	1.5%	-11.4%
0105 Chemical Sciences	1,209	1,143	1,214	1,558	1,143	1,145	1,142	-5.5%	-0.3%
0109 Biological Sciences	10,198	11,011	11,133	11,512	10,952	10,839	10,761	5.5%	-0.7%
Total Enabling Sciences	14,406	15,381	15,600	16,452	15,334	15,059	14,723	2.2%	-2.2%
Total Natural and Physical Sciences*	51,826	52,476	53,311	54,500	53,951	53,939	54,313	4.8%	0.7%

*The data takes into account of Combined Courses to two field of education. As a consequence, counting both fields of education for Combined Courses means that the totals may be less than the sum of narrow fields of education.

Domestic Postgraduate	2001	2002	2003	2004	2005	2006	2007	Change 01-07	Change 06-07
0101 Mathematical Sciences	749	907	919	1,011	959	1,005	1,111	48.3%	10.5%
0103 Physics and Astronomy	833	894	957	1,039	1,010	1,042	1,040	24.8%	-0,2%
0105 Chemical Sciences	1,016	868	888	910	871	933	922	-9.3%	-1.2%
0109 Biological Sciences	3,238	3,502	3,703	3,891	3,523	3,580	3,723	15.0%	4.0%
Total Enabling Sciences	5,836	6,171	6,467	6,851	6,363	6,560	6,796	16.4%	3.6%
Total Natural and Physical Sciences*	8,361	9,014	9,503	10,020	10,094	10,444	10,846	29.7%	3.8%

*The data takes into account of Combined Courses to two field of education. As a consequence, counting both fields of education for Combined Courses means that the totals may be less than the sum of narrow fields of education.

Source: DEEWR, Submission 1.2, p. 5.

3.8 DEEWR stated that enabling sciences made up 62.8 per cent of domestic enrolments in natural and physical sciences. It agreed that interpretation of enrolment data in narrow areas (such as physics, mathematics and chemistry) is determined by the definition of 'enabling sciences'.[7]

3.9 The Department advised that:

> a majority of enrolments in the broad field of natural and physical sciences … are not coded to any particular narrow field. This could reflect the structure of many university science courses where study of different narrow fields is incorporated within broad level science courses.[8]

Timeframe for participation trends

3.10 Dr Ridd argued against the suggestion that enrolment trends are subject only to marginal fluctuations by referring to a longer term drop that has been identified since the early 1990s.[9]

3.11 A large body of research and analysis published by the Australian Council of Deans of Science (ACDS), and other researchers attests to the downward trend in the longer term.[10]

3.12 In 2007, ACDS released the third in a series of reports. The report supports DEEWR's position that based on 2002-05 enrolment data in Natural and Physical Sciences, there is no cause for concern.[11] However, since 1989 there is a long term absolute decline in chemistry, physics and mathematics, which 'ought to ring alarm bells'.[12]

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7 DEEWR, *Transcript of Evidence*, 6 June 2008, p. 13.

8 DEEWR, *Supplementary Submission 1.2*, p. 4.

9 Dr Ridd, *Submission 2*, p. 2.

10 See for example, ACDS, *Trends in Science Education* (1998); I Dobson, *Science at the Crossroads? A study of trends in university science from Dawkins to now 1989 -2003*, ACDS, October, 2003; *Is the Study of Science in Decline*, ACDS Occasional Paper No.3, November, 2003; Ian Dobson, *Sustaining Science: University Science in the Twenty-First Century,* ACDS, February, 2007.

11 Ian Dobson, *Sustaining Science: University Science in the Twenty-First Century,* ACDS, February, 2007, p. 71.

12 Ian Dobson, *Sustaining Science: University Science in the Twenty-First Century,* ACDS, February, 2007, p. 71.

Table 3.2 Student Load 1989 - 2005: Teaching to students enrolled in Natural and Physical Sciences Courses by Discipline Group

All students	1989	1997	2005	Variation 2005 – 1989	
				No.	Per cent
Mathematical sciences	7520	6512	4988	-2532	-33.7%
Physical sciences	3612	3351	2911	-701	-19.4%
Chemical sciences	5932	6753	5617	-315	-5.3%
Earth sciences	2173	3106	2195	22	1.0%
Biological sciences	10648	18658	18624	7976	74.9%
Other	1617	3375	4007	2390	147.8%
Total science disciplines	31502	41755	38342	6840	21.7%

Source: Table 78 Australian Council of Deans of Science (2007), Sustaining Science: University Science in the Twenty-First Century.

3.13 Dr Ian Dobson of the Centre for Population and Urban Research at Monash University has argued that:

> The 'steady as she goes' pattern of 2002-2005 hides the fact that the 1990s saw sharp declines in enabling sciences participation by students enrolled in courses in the Natural and Physical Sciences. The number of enrolments has roughly doubled since 1989, with some uncertainty due to the changes in counting methodology, yet during such a spectacular growth in the system the number of equivalent full-time science students taking chemistry declined by 315 or 5.3 per cent. For physics the decline was 701 about 19 per cent. In 1989 there were 7,520 FTE [Full Time Equivalent] science students enrolled in mathematics; in 2005 this number had dropped to 4,988. This is a decline of 2,532 FTE students, or about one-third.[13]

3.14 The trend among students away from the 'hard sciences' at the secondary school and tertiary level has been observed to be an international phenomenon. The Australian Council for Educational Research (ACER) stated that:

> For the past 20 years most OECD economies have witnessed an increased level of participation in senior secondary and

13 Ian Dobson, *Sustaining Science: University Science in the Twenty-First Century,* ACDS, February, 2007, p. 71.

university education but a declining percentage of students studying science, technology, engineering and mathematics.[14]

Committee comment and recommendation

3.15 Statistics provided by DEEWR conveyed a very different version of the trend in tertiary enrolments in enabling sciences from other stakeholders. One reason for the difference is the limited timeframe for which the Department provided data. Of greater concern is the apparent difficulty of tracing enrolment trends in narrow areas of enabling sciences caused by the aggregations used to compile the Department's data sets.

Recommendation 3

3.16 **That the Department of Education, Employment and Workplace Relations consult with the Australian Council of Deans of Science, the Australian Academy of Science, the Australian Council of Educational Research and other relevant stakeholders in relation to improving collection and aggregation of data on university enrolments and completions that will provide trend information for narrow areas of enabling sciences such as physical, mathematical and chemical sciences.**

Influences on student choices

3.17 A DEST Audit of Science, Engineering and Technology (SET) Skills in 2006, found that the shortage of higher education SET graduates was partly attributed to:

- the lack of SET skills of high school leavers,
- poor careers advice to students and the community in general on SET;
- and the low profile of SET careers.[15]

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14 J Ainley, J Kos, M Nicholas, *Participation in Science, Mathematics and Technology in Australian Education*, ACER Research Monograph No.63, August, 2008., p. 1.

15 DEEWR, *Submission 1*, p. 2.

Secondary school enrolments in sciences

3.18 Dr Terry Lyons, Chair of the International Organization for Science and Technology Education, has observed that over the last two decades, science educators have:

> watched with growing concern the steady decline in the proportion of high school students choosing senior science courses…
>
> Between 1990 and 2001, for example, Year 12 (final year) enrolments in physics, chemistry and biology courses decreased by 23, 25 and 29% respectively … prompting questions about future levels of scientific literacy and technological expertise.[16]

3.19 ACDS referred to a DEST commissioned ACER analysis of enrolment, retention and completion rates in senior secondary school science between 1976 and 2007 that showed participation had declined over the 30 year period.[17]

3.20 The ACER research concluded that:

- since the mid 1990s year 12 retention has stabilised but science participation has continued to decline;
- there is evidence from every state and territory of declines since the mid 1990s of participation in advanced levels of studies in mathematics (these trends continue the declines from earlier periods);
- longitudinal data show that uptake of science related studies at university is stronger amongst those who specialise in science studies in the final year of school; and
- subject choices are influenced by teacher proficiency in mathematics during middle secondary school.[18]

3.21 ACDS stated:

> there can no longer be any doubt that these trends are real, that they are entrenched and that no action taken thus far shows any sign of turning it around … it is very important for

16 Terry Lyons, 'The Puzzle of falling Enrolments in Physics and Chemistry Courses: Putting Some Pieces Together', *Research in Science Education* (2006) 36 285.

17 ACDS, *Transcript of Evidence*, 14 November 2008, p. 71.

18 J Ainley, J Kos, M Nicholas, *Participation in Science, Mathematics and Technology in Australian Education*, ACER Research Monograph No.63, August, 2008, p. 82.

> people to finally get that message, and turn back and start to think about what they are actually going to do.[19]

Availability of quality science teachers

3.22 The Federation of Australian Scientific and Technological Societies (FASTS) stated that lack of high quality science teachers is a significant factor in the overall decline of enabling science education.[20]

3.23 Dr Ridd specified:

> The problem of the lack of knowledgeable Maths/Science teachers, especially in Years 8/9/10 has dreadful consequences, because it is student performance over those three years that is the biggest determinant of enrolments in STEM in Year 11/12.[21]

3.24 ACDS referred to its own studies that showed 'one in twelve [secondary school] mathematics teachers studied no mathematics at university level' and, 'one in five studied no mathematics beyond first year'. One in four year 11 and 12 mathematics teachers had not done a third year level maths subject of any kind at university. Forty per cent of the teachers surveyed were dissatisfied with their mathematics preparation as mathematics teachers.[22]

3.25 The 2007 Trends in International Mathematics and Science Study (TIMSS), found that although there was no significant change in Australia's Year 8 score between 2003 and 2007, there has been a significant drop of 13 score points from that of TIMSS 1995.[23]

3.26 DEEWR agreed that the shortage of qualified science school teachers is a significant factor in tertiary enrolments in enabling sciences:

> in the school sector it certainly is the case that there is a shortage of maths and science teachers. There has been research done on the percentage of teachers who are teaching out of field—teaching in areas they do not have university qualifications in. There is a particular issue, certainly in maths and science, with people who do not have qualifications in

19 ACDS, *Transcript of Evidence*, 14 November 2008, p. 71.
20 FASTS, *Transcript of Evidence*, 16 October 2008, p. 5.
21 Dr Ridd, *Submission 2 Attachment D - STEM Discussion Paper Response*, p. 28.
22 ACDS, *Transcript of Evidence*, 14 November 2008, pp. 71-72.
23 ACER, *Highlights from TIMSS 2007 from Australia's Perspective* (2008), p. 8.

> the area. That is a significant issue and will be a significant issue going forward.[24]

3.27 ACER research has concluded that strengthening school science education depends on deepening teacher expertise in science:

> Deepening teacher expertise depends on recruiting into teaching a greater proportion of people with backgrounds in science, enhancing the science base of practising teachers in science and giving consideration to having specialist science teachers in primary schools. Specialist science teachers in primary schools could provide a core of expertise in those schools.[25]

3.28 ACDS expanded upon the extent of the potential problem:

> At the time of the survey in 2006, 38 per cent of the teachers were aged 49 or over; 15 per cent were aged over 54. Fewer than half of the teachers surveyed were confident that they would be teaching mathematics in five years time. Three in four schools reported difficulty in recruiting suitably qualified mathematics teachers.[26]

3.29 FASTS argued that higher quality teachers with knowledge and networks in the scientific community will be able to provide more stimulating classroom experience. These teachers can also provide informed advice to students choosing university courses and considering a future career in science.[27] FASTS advocated rewarding teachers with higher degrees to encourage high quality teachers to go into the profession.[28]

3.30 ACDS agreed and advocated a fundamental change in the way secondary science education is taught. It is important to:

> get into the schools and show students where this science is applied to generate some excitement … that cannot be at the level where it is happening now, where it becomes an add on … it has to be part of the real curriculum. It also has to be part of teachers' professional lives that they are engaged in those networks and it is part of their job to bring those people in...[29]

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24 DEEWR, *Transcript of Evidence*, 6 June 2008, p. 3.

25 J Ainley, J Kos, M Nicholas, *Participation in Science, Mathematics and Technology in Australian Education*, ACER Research Monograph No.63, August, 2008, p. 83.

26 ACDS, *Transcript of Evidence*, 14 November 2008, p.72.

27 FASTS, *Transcript of Evidence*, 16 October 2008, p. 5.

28 FASTS, *Transcript of Evidence*, 16 October 2008, p. 5.

29 ACDS, *Transcript of Evidence,* 14 November 2008, p. 72.

Strategies to encourage young people into 'enabling sciences'

3.31 DEEWR identified two responses to the issue of declining tertiary enrolments in enabling sciences:

- the removal of obstacles at the tertiary entrance level; and
- the active promotion of teaching and learning science and mathematics in primary and secondary schools.

3.32 The Department is implementing the following strategies to remove obstacles to studying science and mathematics subjects at tertiary levels:

- reducing the student contribution for maths and science from $7,402 to the lowest national priority rate of $4,162 (commencing 2009 but not applicable to students currently enrolled in science or mathematics subjects[30]),
- reducing the compulsory repayments by up to $1,500 per annum over five years for eligible maths and science graduates who take up related occupations; and
- doubling the number of scholarships available for low income students, from 44,000 to 88,000 by 2012.[31]

3.33 DEEWR identified the following programmes that focus specifically on the promotion of teaching and learning science and mathematics subjects in primary and secondary school:

> - The *Scientists in Schools* project involves [CSIRO] scientists establishing ongoing partnerships with primary and secondary schools…
> - The *Science by Doing* project, led by the Australian Academy of Science, is developing a new approach to science teaching and learning for the junior secondary years…
> - The *Primary Connections* program, also led by the Australian Academy of Science, is developing curriculum units and professional learning programs for teachers aimed at improving primary students' knowledge of science…
> - Provision of $1 billion as a long term investment for Science and Language Centres for 21st Century Secondary

30 DEEWR, *Supplementary Submission 1.2*, p. 1.

31 DEEWR, *Transcript of Evidence*, 6 June 2008, p. 3.

> Schools to build around 500 new science laboratories and language learning centres…[32]

3.34 Besides the Scientists in Schools Program, CSIRO referred to other initiatives at the school level, including:

- the Discovery Centre, with 30,000 to 40,000 children visiting a year; and
- education centres that go into schools.[33]

3.35 The Australian Nuclear Science and Technology Organisation (ANSTO) advised that education and training is a designated function under the *Australian Nuclear Science and Technology Organisation Act 1987* (ANSTO Act). It forms one of the six outputs under ANSTO's funding framework.[34] ANSTO has a role in contributing to science and mathematics education generally, as well as specifically in relation to nuclear science and technology at both school and tertiary level.

3.36 ANSTO has a full time education specialist and a team of tour guides. In the last financial year ANSTO hosted 145 school tours and 4,662 school visitors. School tours are integrated into school curricula, and may be tailored to specific needs. For senior students, a senior chemistry workbook and senior physics workbook provide structured questions that are part of the curriculum studies.[35] ANSTO also provides education resources for junior science curricula and for senior level physics and chemistry, which are freely available from the website. Professional development days are hosted for teachers and principals.

3.37 ANSTO facilities are used by science academics and students:

> Last year we co-supervised about 100 students. Typically, a main supervisor will be from a university and an ANSTO staff member will be a co-supervisor helping that student when they use our facilities and providing our particular expertise.[36]

3.38 ANSTO stated that one in seven of its own staff hold positions at universities, an honorary, adjunct or similar position from professorial to lecturing roles. ANSTO also works with postdoctoral

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32 DEEWR, *Submission 1.2*, p. 2.

33 CSIRO, *Transcript of Evidence*, 16 October 2008, p. 5.

34 ANSTO, *Transcript of Evidence*, 14 November 2008, p. 56

35 ANSTO, *Transcript of Evidence*, 14 November 2008, p. 56.

36 ANSTO, *Transcript of Evidence*, 14 November 2008, 2008, p. 57.

fellows at Cooperative Research Centres as well as providing support for its own postdoctoral fellows.[37]

Committee Comment

3.39 Reference was made to a large body of published research on science education at secondary and tertiary level. Much of this evidence suggests that, while science has expanded as a category of university study, there has been a decline in enrolments in 'enabling sciences'. There is evidence of a long term decline in participation in mathematics, physics and chemistry and this is an international phenomena affecting developed economies. It is the subject of ongoing study by the OECD and policy discussion in major developed western countries.

3.40 Despite some disagreement over interpretation of data, there is a strong consensus on the importance of encouraging young people into science education. Organisations like ANSTO and CSIRO promote knowledge and understanding at all levels of the education system and build future research capacity. Peak representative bodies also provided high quality evidence, with informed analysis and clear ideas about the future directions necessary to raise participation levels.

3.41 Stakeholders agreed that a more integrated approach across secondary, tertiary, academic and industry sectors would promote tertiary enrolments in enabling science. Furthermore, there needs to be an emphasis on making science more exciting, demonstrating its practical application to every day life at school level.

3.42 There was consistent evidence on the need to improve secondary science teaching and opportunities to engage students in the enabling sciences. This should be considered as part of the debate on the national science curriculum.

Sharon Bird MP
Chair

20 May 2009

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37 ANSTO, *Transcript of Evidence*, 14 November 2008, 2008, p. 57.